SCIENCE ABSTRACTS.

Section A.—PHYSICS.

JUNE 1921.

GENERAL PHYSICS.

967. *Photographic Chronograph for Small Time Intervals.* **A. Guillet.** (Comptes Rendus, 172. pp. 314–317, Feb. 7, 1921.)—The essential parts of the apparatus described are a tuning-fork carrying a spherical mirror, which gives an image of a luminous point source on a drum driven by clockwork. When the fork is maintained in vibration a luminous streak is given on the drum if the latter is at rest, and a wavy curve when the drum rotates. To register time intervals a sudden sideways motion is given to the mirror, resulting in a displacement of the wavy curve, at the beginning of the interval, and the original position is restored at the end of the interval; or the point source may be moved to obtain the same result. The cylinder carries photographic paper, and on developing, the time interval is at once obtained from the number of vibrations of the fork (whose period is accurately known) between the two displacements of the curve. For longer periods a film may be used. A. W.

968. *Some Slide-Rule Improvements.* **J. S. V. Pletts.** (Phys. Soc., Proc. 33. pp. 57–61; Disc., 61, Feb., 1921.)—The relation existing between the log.-log. scale and the log. scale in slide-rules at present on the market is dealt with, and it is shown that if this relation is made that of the common logarithm the properties of characteristics and mantissæ enable the range of the non-recurring log.-log. scale to be indefinitely extended. In addition an equally divided scale is arranged to give ae^x and $\log_e ax$, where a is a number on the log. scale, and scales for all the circular and hyperbolic functions are arranged on the back of the slide so as to read on the log. scale. All such functions as $e^n \sin x$ and $\log n \cosh x$ are, therefore, obtained with a single setting of the slide and cursor. Other minor modifications are made, and a cursor for magnifying and subdividing the divisions is described. Author.

969. *Clock Escapement on Free Escapement Principle.* **G. Féry.** (Comptes Rendus, 172. pp. 205–208, Jan. 24, 1921.)—A description is given of a simple method of applying the free escapement principle to clock pendulums. The pivoted escapement "anchor" carries a horizontal lever, provided on one side with a small balance weight, which brings the end of the lever up against an adjustable stop when the other end of the lever is not acted on by the pendulum. The pendulum is furnished with a stone or crystal, whose section (in a plane parallel to the plane of oscillation of the pendulum) is a segment of a circle with the curved part downwards. The end of the lever carries a similar stone with the curved part upwards, and when the pendulum oscillates, the two stones engage and the end of the lever is depressed, actuating the escapement. After the pendulum has passed the vertical position the end of the lever rises again, due to the balance weight and the pressure exerted on one end of the anchor by a tooth of the escapement wheel. The pendulum thus receives an impulse once in each swing, and the motion is maintained. The total energy imparted to the pendulum is independent of the balance weight, depending only on the impulses due to the two arms of the anchor. The arrangement has been found to work very well. A. W.

970. *The Directional Hot-wire Anemometer; Sensitivity and Range of Application.* **J. S. G. Thomas.** (Phil. Mag. 40. pp. 640–665, Nov., 1920.)—Gives a quantity of additional experimental results showing the behaviour of the anemometer already described [Abs. 1031 (1920)]. L. H. W.

971. *The Hot-wire Inclinometer; Influence of Gas Surrounding the Wires.* **R. H. Humphry.** (Phys. Soc., Proc. 33. pp. 190–193; Disc., 193–195, April, 1921.)—Two fine Pt wires were stretched parallel to each other in a hole in a copper block, and were heated electrically in a Wheatstone bridge arrangement. The changes caused by rotation were investigated with hydrogen, air, and carbon dioxide surrounding the wires. It was found that both for the same current, and for the same temperature of the wires, the inclinometer filled with CO_2 was much more sensitive than one filled with air. The shape of the curves obtained suggests that the temperature gradient in the region traversed by the wires is nearly uniform, the difference of temperature of the layers of gas in which the wires find themselves being sensibly proportional to the vertical distance between them. AUTHOR.

972. *Graphical Method for Frequencies of Lateral Vibrations and Whirling Speeds for Non-uniform Rod.* **R. V. Southwell.** (Phil. Mag. 41. pp. 419–431, March, 1921.)—A mathematical solution is here developed which gives a close approximation for certain important cases, and lends itself to graphical exhibition. The paper is illustrated by a number of figures, and includes a valuable bibliography. Results within one per cent. are shown to be obtainable. E. H. B.

973. *Errors Involved in Solving for the Constants of Fourier's Series by a Calculation Method.* **W. Mason.** (Phys. Rev. 17. pp. 315–321, March, 1921.)—I. *Sources of error* due to measurement and due to higher harmonics.

II. *Error due to measurement.*—(*a*) Determination due to the placing of the ordinates and the measurement of the ordinates. (*b*) Formula evolved for probable error. (*c*) Error plotted to number of ordinates used.

III. *Error due to the assumption that no harmonics above the mth exist.*—(*a*) Formula derived for error due to the presence of higher harmonics. (*b*) Determination and plotting of the error in a constant-ordinate curve. 1. Reason why the error in this sort of a curve is fairly representative. (*c*) Determining the best conditions to analyse a wave-form. (*d*) Error due to the higher cosine harmonics. *(d)* Formula for the error when the even harmonics are considered. AUTHOR.

974. *Theory of Irreversible Time Effects.* **M. D. Hersey.** (Washington Acad. Sci., J. 11. pp. 149–155, April 4, 1921.)—The aim of this paper is to formulate the problem of time effects, meaning transient or recoverable effects as distinguished from permanent changes, and to develop methods of analysis for use in subsequent research. The general problem of irreversible time effects is to deduce the displacement–time curve when the load–time curve is given. When the problem has been solved in this general way the solution will be found to embrace, as particular cases, all such special effects as the discrepancy between static and dynamic modulus; residual displacement after load; phase difference between a periodically varying load and the corresponding displacement; time needed for approaching the cyclic state, a state in which the hysteresis loop has an invariable form; or the damping of free vibrations. The formulation need not be restricted to elastic lag phenomena. It applies to all irreversible effects measured by some quantity x, whose value is fixed by the history of some other quantity X. x may be termed the generalised displacement and X the generalised load. A. W.

975. *Effect of the Suspension Band of a Clock Pendulum; Experiments and Theory.* **P. Le Rolland.** (Comptes Rendus, 172. pp. 664–666, March 14, and pp. 800–802, March 29, 1921.)—*Experimental.*—The steel band, by which a clock pendulum is suspended, is intended to compensate for the circular errror arising from amplitudes greater than infinitesimal. In these experiments such a clock pendulum is compared in action with a Borda pendulum on a knife-edge, the ratio of frequencies of the two pendulums being found by Lippmann's method [see Abs. 161 (1897)], which is considered incomparably more exact than the method of coincidences. It is found, for a variety of steel bands employed, that as amplitude is increased the frequency first increases, reaches a maximum for an amplitude of 1°, then decreases, at first rapidly and then more slowly. An expression is found for the relative change in frequency: $\Delta T/T = A\theta_0 - B\theta_0^2 + C\theta_0^3$, where $\theta_0 =$ amplitude, and A, B, C are positive constants. The second term, $B\theta_0^2$, is the most important in compensating the circular error. A long, thin steel-band suspension is found to produce less disturbing effect on isochronism than a short thick one; but the latter is most useful when, as in practice, it is desired to compensate for circular error.

Theory.—In the second article the theory of the suspension band is worked out mathematically, and it is found that this does not completely account for the action of an ordinary clock pendulum. The accordance between theory and experiment breaks down for considerable amplitudes. P. E. S.

976. *Young's Modulus and Poisson's Ratio by Method of Flexures.* **H. Carrington.** (Phil. Mag. 41. pp. 206–210, Feb., 1921.)—Describes apparatus used for determining Young's modulus and Poisson's ratio in the case of timber. For spruce the value of Poisson's ratio in the case of lateral strain in the direction of the grain is about 0·01. Values obtained by this method in the case of various metals are compared with those obtained by the extensometer. It was found that with strips

0·75 in. wide and 0·13 in. thick the radius of curvature of flexure could be reduced to 40 in. without any indication of failure of the method.

J. W. T. W.

977. *Study of Shock Tests on Notched Bars.* **A. Cornu-Thénard.** (Rev. de. Mét. 17. pp. 536–554, Aug.; 584–614, Sept., and pp. 648–667, Oct., 1920.)—In constructional steel in the quenched and tempered condition the speed of the blow has an appreciable influence, the impact value being lowered by from 5 to 20 % when this is decreased from 9 m. per sec. to 60 mm. per hour. A decrease in the diameter of the notch from 4–1·3 mm. lowers the impact value by from 10 to 30 %. In the normalised condition the slower speed of blow gives rather better impact values. Dead-mild steels of very coarse crystallinity, on the other hand, are extremely sensitive to the speed of impacts, and reducing this from 8·8 to 2·70 m. per sec. doubles the value obtained, while with very slow speeds the value may be increased to four-fold. It is thus considered that high velocities of impact are required to pick out brittle material of this type. Equally is a small notch necessary, as, with a notch of large diameter (4 mm.), coarse-grained, overheated mild steel appears tougher than correctly treated nickel-chrome steel. The **V** notch, depth 2 mm., angle 45°, and radius at root 0·25 mm., picks out brittleness as well as or better than do notches of the Copenhagen type. The author considers, however, that the Charpy notch is the better. In normal material, where the influence of the velocity of impact is negligible, three periods are distinguished during fracture: (1) an elastic period without permanent deformation, (2) a plastic range of deformation ending with the commencement of formation of a crack at a stress which corresponds with the max. stress of the material, and (3) the stage of propagation of the crack across the test-piece. It is in this range that information not given by the tensile test is obtained. In those cases in which the speed of impact is of importance only stages (1) and, in part, (2) are found; stage (3) being very small, the fracture being probably inter-crystalline, no law of similitude of test-piece is found to hold, since stage (2) is, in test-pieces 10 mm. × 10 mm., much more developed than in pieces 30 mm. × 30 mm.

F. C. T.

978. *Repeated Impact Tests; Influence of Speed, Depth of Notch, etc.* **L. Guillet.** (Rev. de Mét. 18. pp. 96–100, Feb., 1921. Paper read before the Assoc. des Méthodes d'Essais.)—The author draws attention to a previous paper by Nusbaumer [Abs. 970 (1915)], in which it is stated that, other things being equal, a metal resists fracture under repeated loading tests (whether by shock, bending, or other methods) in proportion as it resists single-blow shock tests. He emphasises the clause "other things being equal," and describes tests made on various materials to study the influence of other factors, such as speed and strength of blows, depth of notch, etc. *Effect of Quenching.*—Tests carried out on a low and a medium carbon steel, both annealed and quenched, show that quenching raises the tensile strength, the shock strength, the elastic limit, and the number of blows required for fracture. Experiments on a steel containing 0·25 % carbon, 4·4 % Ni, and 1·2 % Cr, and on one containing 0·1 % of carbon, 6·5 % Ni, and 0·15 % Cr, show that, in both cases, the resistance to repeated impacts depends much more on the tensile strength than on the shock strength. It would appear, also, that the depth of the notch in the repeated impact test-piece has a much greater influence on quenched than on annealed metal (mild steel). The author concludes by stating that most fractures are due to repeated stress, and that it is often more advantageous to use a steel with a high elastic limit, than one with a very high shock strength and a low elastic limit. J. L. H.

979. *Study of the Brinell Test; Sources of Error; Machine with Automatic Compensation.* **R. Guillery.** (Rev. de Mét. 18. pp. 101–110, Feb., 1921.)—In carrying out a rapid Brinell test two sources of error are present. The first is that it is very difficult not to overshoot the max. load, while the second is due to the fact that under a constant load the ball continues to sink into the specimen for a period which may be as long as 5 minutes. These two errors oppose one another, and it is possible, by choosing suitable conditions, to carry out a rapid test in which they cancel each other. The author describes a machine in which this compensation is automatically obtained.

Two other pieces of apparatus for carrying out Brinell tests are described. In the first the compression of a spring under the blow from a hammer is used to load the ball, while in the second the energy from a standard weight, falling from a constant height, gives the necessary load. J. L. H.

980. *Aeroplane Photo Surveying.* **C. G. Lewis** and **H. G. Salmond.** (Survey of India, Professional Paper No. 19 [53 pp.], Dehra Dun, 1920.) —Describes experiments carried out in the Agra district with the object of determining the relative advantages of the aeroplane photo method, and the ordinary trigonometrical method of surveying for maps of various scales. It is concluded that the air method is much more costly than ordinary methods, and that nothing is to be gained by adopting it for normal 1-in. surveys in India. For the larger scales it might prove more advantageous. One of the principal difficulties is the inability of the pilot to follow accurately a predetermined course. A diagram is given at the end of the paper, showing the courses actually followed by the pilot during the trials. J. W. T. W.

981. *Rolling Friction.* **J. Andrade.** (Comptes Rendus, 172. pp. 798–799, March 29, 1921.)—Describes apparatus for the photographic recording of the swing decrements of a cylinder used for the determination of friction of a cylindrical roller. The method depends on the production of a narrow pencil of light by means of light-weight optical apparatus fixed to the moving cylinder. J. W. T. W.

982. *Flow of Liquid from a Suddenly Opened Nozzle.* **H. Villat.** (Comptes Rendus, 172. pp. 148–150, Jan. 17, 1921.)—A mathematical discussion of the effect of orifice form on the distribution of pressure following the sudden opening of an orifice in a vessel of liquid. J. W. T. W.

983. *Wind-Tunnel Experiments in Compressed Gases.* **J. Villey.** (Comptes Rendus, 172. pp. 270–272, Jan. 31, 1921.)—Referring to Margoulis' suggestion to carry out wind-tunnel experiments in CO_2 under pressure [see Abs. 350 (1921)], the author points out that in such experiments the introduction of forces not ordinarily important might render it unsafe to extrapolate from results obtained in one gas to predict those to be expected in another. He considers that such experiments would serve more usefully as complementary to the present experiments in air, than instead of them. J. W. T. W.

984. *Wave Propagation in Isotropic Media.* **G. A. Maggi.** (Accad. Lincei, Atti. 29. ii. pp. 371–378, Dec. 19, 1920.)—This paper is mainly mathematical, and cannot be usefully abstracted. J. W. T. W.

985. *The Aerodynamics of a Spinning Shell.* **R. H. Fowler, E. G. Gallop, C. N. H. Lock, and H. W. Richmond.** (Roy. Soc., Phil. Trans. 221. pp. 295–387, Dec. 3, 1920.)—This monograph should be consulted by those interested, as no short abstract would be of value. L. H. W.

986. *The Stability of Fluid Motion.* **T. H. Havelock.** (Roy. Soc., Proc. 98. pp. 428–437, March 3, 1921.)—Mathematical.

987. *Initial Movement of a Liquid in Contact with an Obstacle with Sharp Edges.* **D. Riabouchinski.** (Comptes Rendus, 172. pp. 521–522, Feb. 28, 1921.)—The subject is mathematically treated. A few of the numerical values of expressions arising are tabulated. A. B. C. L.

988. *Friction and Lubrication.* **R. M. Deeley.** (Engineer, 131. pp. 74 and 78, Jan. 21, 1921.)—The first paper is the preliminary report (not previously published) communicated to the Lubricants and Lubrication Inquiry Committee of the Department of Scientific and Industrial Research on Dec. 5, 1918. It contains an illustration of the author's oil-testing machine, but otherwise covers much the same ground as a previous paper by the same author [Abs. 495 (1920)]. The second paper is a leading article dealing with the report. The opinions are expressed that :—(1) The observations at present available are still far from being sufficient to permit the pronouncement of a critical judgment on the validity of the author's theory ; (2) the partially lubricated bearing is hardly more efficient than a dry bearing and should be avoided in practice. The exact laws governing partial lubrication can, therefore, have little direct practical application. At the same time it is recognised that if chemical action is at the basis of partial lubrication it must also enter in some degree into complete lubrication, and that such a revolutionary belief could not be established without affecting our whole outlook on all the problems of lubrication. For the time being judgment must be suspended ; not till a great deal of confirmatory work has been carried out can it be accepted without reserve. G. W. DE T.

989. *On the Varied Motion of Fluids.* **L. Lecornu.** (Comptes Rendus, 172. pp. 350–353, Feb. 14, 1921.)—In the non-permanent motion of a fluid, three curves converging towards any fixed point may be considered at each instant, which are defined as follows : (1) the trajectory of the successive positions taken up by a molecule, which is at the fixed point at the instant considered ; (2) the file of molecules, *i.e.*, the line of positions occupied by all the molecules which have passed or will pass through the fixed point about the given instant ; (3) the current line through the fixed point. These three curves are closely investigated in the present paper, which is mathematical throughout. H. H. Ho.

990. *Flow of Gas at Low Pressures through Capillary Tubes.* **G. W. Todd.** (Univ. of Durham Phil. Soc., Proc. 6. 1. pp. 8–15, 1920.)—The laws for the flow of gas through tubes at ordinary pressures and at extremely low pressures, where the mean free path of the molecules approaches the dimensions of the measuring apparatus, are very different, and are inadequate to express the facts for intermediate pressures. Experiments are described having for their object the finding of an empirical expression for the flow of a gas through a tube which would represent the facts for all pressures. A large number of readings are tabulated for air and hydrogen with capillary tubes of various ascertained dimensions. These results are plotted, and it is found that the viscosity of air flowing along a tube of circular cross-section is a function of the product of mean pressure into the diameter. The form of the function is discussed, and the relationships arrived at are compared with Knudsen's formula. A. B. C. L.

991. *The Equilibrium Law of Solid Granules Subjected to a Current of Vertically Ascending Water.* **R. Feret.** (Comptes Rendus, 172. pp. 575–578, March 7, 1921.)—The procedure usually adopted for determining the granular composition of fine powders, is that of weighing the grains which are not carried away by liquid or gaseous currents rising vertically and of graduated velocities. The conditions obtaining during this process are investigated in the paper. For grains all of the same shape, if l be one of their homologous linear dimensions, d the density, and d' the density and v the speed of the fluid, then for grains just in equilibrium, *i.e.*, neither carried away nor deposited, the apparent weight of a grain is equilibrated by the resistance of the fluid, this leading to the formula $v = \mathrm{A}\,[l(d - d')/d']^{1/2}$ or $l = \alpha(d'v^2)/(d - d')$, where A and α are numerical coefficients dependent especially on the average form of the grains. On the other hand, Stokes has deduced, by purely theoretical considerations, an entirely different relation for a small sphere falling slowly through a viscous fluid, viz., $v = \mathrm{B}\,(d - d')l^2$ or $l = \beta[v'(d - d')]^{1/2}$, where l is the diameter; B and β are constants which have values of 545 and 0·043 in the case of water at 20° when the units are the millimetre and the second. Richards found that the motion followed either of the above laws according as the grains were greater or less than a certain critical size. Data are quoted by him for galena and quartz. Experiments are described by the author for grains in equilibrium in an ascending current of water flowing through vertical tubes; coal dust, silica, quartzite, iron sulphide, and litharge particles were employed. When the section of the grain is negligible in comparison with that of the tube, Stokes' law appears applicable in every case. The coefficients for different materials present divergences entirely independent of density and differing from the theoretical numbers. From these results the conclusion is drawn that the phenomena are not the same when the particle is in equilibrium in an ascending fluid, as when it is itself descending through a fluid at rest. H. H. Ho.

992. *Motion of a Sphere of Oil through CO_2; Determination of Viscosity by the Oil-drop Method.* **L. J. Lassalle.** (Phys. Rev. 17. pp. 354–366, March, 1921.)—I.—*Coefficient of Viscosity of CO_2 by the Oil-drop Method.*—The value of e being known, through work in air, to an accuracy of about 0·1 %, the oil-drop method as developed by Millikan has been used in CO_2 for the determination of the coefficient of viscosity of that gas; the result is, at 23° C., $\eta = 1{\cdot}490 \times 10^{-4}$.

II. *Coefficient of Slip between* CO_2 *and Oil.*—The value of the constant A in Millikan's equation $e_1 = e(1 + Al/a)^{3/2}$ is found in CO_2 to be 0·8249 as against Millikan's value in air 0·864.

III. *Variability of the Constant* A *for Values of* l/a *Greater than* 0·5. —Precisely as in Millikan's work in air, A was found to be constant only up to $l/a = 0{\cdot}5$, beyond which it kept increasing as far as it was followed, viz., up to $l/a = 12$. **Author.**

993. *Dynamics of Capillary Flow.* **E. W. Washburn.** (Phys. Rev. 17. pp. 273–283, March, 1921.)—*Penetration of Liquids into Cylindrical Capillaries.*—*The rate* of penetration into a small capillary of radius r is shown to be: $dl/dt = P(r^2 + 4er)/8\eta l$, where P is the driving pressure, e the coefficient of slip, and η the viscosity. By integrating this expression, the *distance penetrated by a liquid flowing under capillary pressure alone* into a horizontal capillary or one with small internal surface is found to be the square root of $(\gamma rt \,.\, \cos\theta/2\eta)$, where γ is the surface tension, and θ the angle of contact. The quantity $(\gamma \cos\theta/2\eta)$ is called the coefficient of penetrance, or the penetrativity, of the liquid.

Penetration of Liquids into a Porous Body.—(1) *Theory.*—If a porous body behaves as an assemblage of very small cylindrical capillaries, the volume which penetrates in a time t would be proportional to the square root of $(\gamma t/\eta)$. (2) *Experiments with mercury, water, and other liquids* completely verify the theoretical deductions.

A dynamic capillary method of measuring surface tension is described which possesses certain advantages on the static method of capillary rise. **Author.**

994. *The Dynamics of Golf Balls.* (Nature, 107. pp. 207–210, April 14, 1921.)

995. *Atomic Structure and Scattered Radiation.* **R. Glocker** and **M. Kaupp.** (Ann. d. Physik, 64. 6. pp. 541–565, March 31, 1921.)—In consequence of the regular arrangement of the electrons in the atom and also, as Debye has shown, by reason of the irregular orientation of the atoms due to the incidence of electromagnetic waves, interference effects must occur so that the intensity of the radiation scattered by the atoms exhibits maxima and minima with respect to its spacial distribution. A quantitative proof of the theory by means of experimental data was not possible at the time owing to the scanty evidence with respect to atomic arrangement. The latter has now been remedied by the phenomenal development of Röntgen spectroscopy, especially for the case of the lighter elements at the peaks of the periodic system. The possibility now occurs of calculating the scattering effect by such definite atoms as carbon, aluminium, etc., and comparing the results with the experimental data. The execution of this intention demands an extension of the Debye theory to electronic systems which consist of 2 and 3 rings. A difficulty now arises in that the distances apart of the electrons in the different rings are no longer constant, but are periodic functions of the time, since the angular velocities of the electrons vary in the different orbits. Section 1 of the paper investigates the scattering effect of an electronic system consisting of several concentric coplanar circular rings.

Section 2 deals with the carbon atom. At present the carbon atom is regarded as a double-ringed electronic system. With respect to the distribution of the electrons two cases appear equally probable, namely: (1) the assumption of an inner ring (K-ring) consisting of two electrons (which is supported by the periodic system), and (2) a K-ring of 3 electrons as required by recent exact calculation of the frequency of the K_a-line. The object of the present paper is to establish whether experimental observations of the scattering effect permit of a decision between these two possible atomic structures. It is found that an inner ring with 2 and an outer ring with 4 electrons corresponds best with both theory and experiment. Section 3 deals with the aluminium atom, which is the most favourable example of a 3-ringed electronic system for the calculation of the scattering effect. Combined evidence from the periodic system and Röntgen spectroscopy supports the electronic distribution of either 2 in the inner, 8 in the middle, and 3 in the outer ring, or an order of 3, 9, 1. A definite solution has not yet been found. The paper is mathematical throughout. H. H. Ho.

996. *Effective Cross-section of Gas Molecules towards Slow Electrons; Non-dependence upon the Gas Pressure.* **C. Ramsauer.** (Ann. d. Physik, 64. 6. pp. 513–540, March 31, 1921.)—A *method* is described whereby the effective cross-section of gas molecules is determined by means of slowly-moving electrons having a definite single velocity and definite path. Such electrons after passing through the gas at known pressure are analysed in a magnetic field, their distribution and intensity being carefully measured. This procedure is repeated for the same gas at varying pressures from " vacuum " to about 0·07 mm. of mercury. The electrons are produced photoelectrically by means of a mercury-vapour lamp.

The following table gives a summary of the results obtained :—

Gas.	Pressure in 10^{-4} mm.	Velocity of Electrons in Volts.	Effective Cross-section q in 10^{-18} cm.^{2}.	a (Mean).
Air	33 67 131	0·80	890	31·0
Hydrogen	41 to 121	0·85	1260	43·8
Nitrogen	96 to 104	0·75	920	31·9
Helium	138 to 151	0·75	550	19·1
Argon	111 to 711	0·8 1·1	75 160	2·6 5·5

The observations show that the effective cross-section of the molecule is independent of the gas pressure, within the limits of pressure indicated in the table. A. B. W.

997. *Structure of the Molecule and Chemical Combination.* **J. J. Thomson.** (Phil. Mag. 41. pp. 510–544, March, 1921.)—Many of the results in this paper were given by the author in lectures at the Royal Institution between 1914 and 1919, but pressure of other duties has hitherto prevented publication. " From many points of view the structure of the molecule is even more important than the structure of the atom. For the structure of the molecule involves the method by which the atoms are linked together to form stable systems of different kinds, and is thus at the root of the enormously important question of chemical combination. In fact the extension of the electronic theory of matter to chemistry depends on the solution of the problem of the structure of the molecule." The author elaborates this point of view in deducing the peculiarities of molecular structure and chemical combination from recent available data regarding electronic and atomic structure.

A clear concise abstract of the paper is not possible. A. B. W.

998. *A Method for the Determination of the Density of Microscopic and Ultra-microscopic Particles; a Contribution to the Problem of the Existence of Electrons.* **R. Bär.** (Ann. d. Physik, 59. 5. pp. 393–408, Aug. 5, 1919.)—Ehrenhaft and his pupils from their observations of ultra-microscopic particles have claimed to establish electric charges smaller than 3×10^{-13}, e.s. unit, while from Millikan's experiments on microscopic particles the existence of an indivisible electricity atom of $4{\cdot}774 \times 10^{-10} \pm 0{\cdot}005$, e.s. unit, follows. In order to bring these results into harmony, the opinion has been expressed by different authorities that the Ehrenhaft experimental conclusions are invalidated by two sources of error, namely: (1) the Stokes-Cunningham resistance law employed by Ehrenhaft is no longer valid with spheres of radius $(2 - 100) \times 10^{-6}$ cm.; (2) the observed particles have a smaller density than that of the compact material from which they are derived, and their shape deviates considerably from the spherical. Since Targonski and Silvey have recently prepared particles of radii $(2–10) \times 10^{-5}$ cm. by methods different from that of Ehrenhaft, and obtained charges which were in excellent agreement with those of Millikan, the Stokes-Cunningham resistance law is held to be valid, and only the second source of error requires consideration. It is now shown that by measuring the velocity of fall of microscopic particles under different gas pressures, their radii and density can be determined on the basis of a given resistance law. Platinum, gold, and silver particles produced in air in direct-current short sparks, and Pt and Al particles of $(2–10) \times 10^{-5}$ cm. radius formed in alternating-current sparks, either possess a sponge-like structure or show great deviations from the spherical shape. Absolute charge measurements on such particles are therefore inadmissible. A future paper will contain an investigation, for particles of $(2–20) \times 10^{-6}$ cm. radius, of the resistance-law which best accords with the observed connection between velocity of fall and free path. H. H. Ho.

999. *The Spherically Symmetrical Gravitational Field in a World Free from Electricity.* **E. Reichenbächer.** (Ann. d. Physik, 64. 7. pp. 577–608, April 19, 1921.) [See Abs. 19 (1921).]—This paper, which is entirely mathematical, deals with the subject under the following sections:—(1) Supplementary and modified forms of the field equations; (2) Determination of the fundamental component g_{11}; (3) Field equations; (4) The equations of the electrically free gravitational field; (5) Influence of the resisting medium. By a change in the conditions of variation in the world-function, a wider coordinate invariant equation has been obtained between the magnitudes of the gravitational and electromagnetic field. The conditions were then investigated under which the assumption of a distortion of the static space of the attracting electrons is compatible with the theory of the scalar gravitational potential when this is interpreted as a light-velocity, and especially with the Einstein-Schwarzschild hypothesis for the coordinate system in the spherically symmetrical gravitational field. When the assumption is made that the electromagnetic field disappears—which, while not exact, is true, to close approximation, for planetary motion—the problem becomes greatly simplified and leads to the conclusion that the mass densities agree with those of the gravitational energies. The hypothesis for the coordinate system in the spherically symmetrical gravitational field are then developed, and deviate from the earlier hypotheses of Einstein, where the mass-densities in the field are considered zero. The bending of light and the perihelion movement then receive attention. Only in the second case has a deviation been established. The assumption of a world-space filled with material of the density of gravitational energy is found to exert a very small effect on the planetary orbit. On the other hand the influence of this energy matter upon the bending of light could not be found since this involves electromagnetic magnitudes, as also the effect of the annual refraction of Courvoisier. **H. H. Ho.**

1000. *The Gravitational Field of a Particle on Einstein's Theory.* **F. W. Hill and G. B. Jeffery.** (Phil. Mag. 41. pp. 823–826, May, 1921.) —The solution of Einstein's contracted tensor equation $G_{\mu\nu} = 0$ for a single attracting point mass may be expressed by means of the line element, $ds^2 = -e^{\lambda}dr^2 - e^{\mu}(r^2d\theta^2 + r^2\sin^2\theta d\phi^2) + e^{\nu}dt^2$, where r, θ, ϕ are polar coordinates and λ, μ, ν are functions of r only. One relation between them must be laid down, and this corresponds to the way in which the radius vector r is measured. Perhaps the best known form of the solution is that for which $\mu = 0$, in which case $ds^2 = -\gamma^{-1}dr^2 - r^2d\theta^2 - r^2\sin^2\theta d\phi^2 + \gamma dt^2$, where $\gamma = 1 - 2m/r$, and m is the mass of the particle. De Sitter gives approximate solutions for which $\lambda = \mu$ and $\lambda + 2\mu + \nu = 0$. Difficulty is sometimes felt in applications of the solutions for which λ and μ are different, and this is often met by writing $r + m$ for r, by which, neglecting squares of m/r, $ds^2 = -\gamma^{-1}(dr^2 + r^2d\theta^2 + r^2\sin^2\theta d\phi^2) + \gamma dt^2$, γ having the same meaning as before. The purpose of the present paper is to show that there is an exact solution for which $\lambda = \mu$. **H. H. Ho.**

1001. *A Generalisation of Weyl's Theory of the Electromagnetic and Gravitational Fields.* **A. S. Eddington.** (Roy. Soc., Proc. 99. pp. 104–122, May 2, 1921.)—In the non-Euclidean geometry of Riemann, the metric is defined by certain quantities, $g_{\mu\nu}$, which are identified by Einstein with the potentials of the gravitational field. H. Weyl has shown that, on removing a rather artificial restriction in Riemann's geometry, the expression for the metric includes also terms which are identified with the four potentials of the electromagnetic field. The author believes that Weyl's geometry, far-reaching though it is, yet suffers from an unnecessary and harmful restriction; and it is the object of this paper to develop a still more general theory. In passing beyond Euclidean geometry, gravitation makes its appearance; in passing beyond Riemannian geometry, electromagnetic force appears; what remains to be gained by further generalisation? Clearly, the non-Maxwellian binding-forces which hold together an electron. But the problem of the electron must be difficult, and the author is unable to say whether the present generalisation succeeds in providing the materials for its solution. The paper now communicated does not seek these unknown laws, but aims at consolidating the known laws, while the author hopes to show that in freeing Weyl's geometry from its limitation, the whole scheme becomes simplified, and new light is thrown on the origin of the fundamental laws of physics. The essential point of Weyl's theory is that comparisons of length at different times and places may yield discordant results according to the route of comparison. Accordingly, a particular standard of length should only be used at the time and place where it is; and it is necessary to set up a separate unit of length (interval-length) at every point of space and time. Such a system of unit standards is called a gauge-system, and Weyl's theory proceeds on the view that the gauge-system is arbitrary, just as the coordinate system is. Nevertheless, he recognises that a certain natural gauge-system plays a very important part in physics, and the theory now developed seems to throw new light on its meaning. A deductive study of world-geometry and an inductive study of observational science attack the problem of Nature from opposite ends. The most elementary concepts of experimental knowledge may not appear until a late stage in the deductive treatment. The work falls into two stages: first, the development of a pure geometry of a very general kind; second, a physical theory based on the identification of the geometrical functions with quantities obtained by experimental measurement. The introduction of the natural gauge-system marks the transition from pure geometry to physics. It is a natural impression that in the light of the more general theory Einstein's work must be regarded as only a close approximation. The present paper, however, leads to the conclusion that Einstein's postulates and deductions are exact. The natural geometry of the world is the geometry of Riemann and Einstein, not Weyl's generalised geometry, and the author has sought not the geometry of actual space and time, but the geometry of the world-structure, which is the common basis of space and time and things. This distinction has been emphasised by dividing the paper into geometrical and physical theory. The first part is the so-called geometry of a general kind of relation complex, and is an essay in assigning measure to such a structure. The method is based on an axiom of parallel displacement, *i.e.*, comparability of proximate relations, and the author succeeds in arriving at a quantitative measure of this structure, namely, $^*G_{\mu\nu}$, which breaks up into symmetrical and antisymmetrical parts, $g_{\mu\nu}$ and $F_{\mu\nu}$, the latter being necessarily the curl of a vector. It is at this bifurcation of theory that Einstein begins; he has recognised these two tensors from their physical manifestations, and he expresses no view as to what lies behind them. From $g_{\mu\nu}$ he builds up interval-length, and hence actual space, time, geometry, gravitation, and mechanics; from $F_{\mu\nu}$ he builds the Maxwellian theory of electricity and magnetism. His interval is absolute, being the in-invariant $R_{\mu\nu}dx_\mu dx_\nu$; so that his work stands unaffected by the ambiguity of length-comparisons in the initial stages of theory. The material he employs is furnished by theory in exact accordance with his specification. The author also shows that there is a more comprehensive measure of the structure given by $^*B_{\mu\nu\sigma\rho}$, of which $^*G_{\mu\nu}$ is an abbreviated summary; the star indicating quantities generalised from the corresponding quantities in Riemannian geometry.

H. H. Ho.

1002. *Relativistic Modification of Parabolic Trajectory.* **W. B. Morton.** (Phil. Mag. 40. pp. 674–677, Nov., 1920.)—The simplest accelerated motion of a particle moving in a straight line with constant "rest-acceleration" was called by Born [Abs. 1723 (1909)] "hyperbolic motion" because the distance-time graph, or "world-line," has that form. The next simplest corresponds to the parabolic path under gravity—*i.e.*, when the particle has rest-acceleration constant in magnitude and direction, but possesses a velocity component perpendicular to this direction. Taking the origin at the point where the velocity, u, is perpendicular to the acceleration, the rest-acceleration is derived from the ordinary acceleration as estimated from a "fixed" standpoint by multiplying the tangential component by γ^3 and the normal component by γ^2, where $\gamma = 1/(1 - v^2/c^2)^{1/2}$. Then the equations of motion are $\gamma^3 v dv/ds \,.\, \cos\phi - \gamma^2 v^2/\rho \,.\, \sin\phi = 0$ and $\gamma^2 v^2/\rho = f \cos\phi$, where f is the constant resultant of $\gamma^3 v dv/ds$ along the tangent and $\gamma^2 v^2/\rho$ along the normal in the direction $0y$, where axes of x and y are taken in the direction of the tangent and the acceleration, respectively, at the origin, and ϕ is the inclination of the tangent at xy to the x axis. Putting $v = c \sin\theta$, $\tan \frac{1}{2}\theta \cos\phi = \text{const} = \tan \frac{1}{2}\theta_0$, say, and it is seen that for θ small the equation reduces to $v \cos\phi = \text{constant}$, in accordance with elementary theory. Introducing an angular parameter α defined by the equation $\sin\alpha = \tan \frac{1}{2}\theta_0 = \left\{c - (c^2 - u^2)^{1/2}\right\}/u$, the relation between the magnitude and direction of v is obtained in a simple form, and the linear scale of the path is found to be expressible in terms of the parameter of the parabola which would be described on the old theory, $a = u^2/2f = rc^2 \sin^2 \alpha/f(1 + \sin^2 \alpha)^2$. The radius of curvature ρ is then expressible in terms of ϕ and the constants a and α, and the integral of this equation is the intrinsic equation of the path. Expressions are then obtainable for the coordinates of a point on the path, and the relation between ϕ and the time is derived. The equation shows immediately that as ϕ approaches the value $\pi/2 - \alpha$, x, y, and t become infinite and v approaches c. That is to say, the direction of motion, instead of swerving through a right angle and approaching coincidence with the acceleration, as in the parabolic case, is turned through $\pi/2 - \alpha$, and the particle approaches a steady motion at the speed of light in a direction inclined at an angle α to that of the constant "rest-acceleration." The author gives graphs of the path for different values of ϕ, for the case $u/c = 0{\cdot}8$, $\alpha = 30$, the parabola with the same "a" being shown for comparison.

G. W. DE T.

1003. *Einstein's Law for Addition of Velocities.* **W. B. Morton.** (Phil. Mag. 40. pp. 771–774, Dec., 1920.)—The author gives and discusses three interesting sets of curves, which show how very simply and clearly the manner in which relativity theory modifies the law of combination of velocities may be illustrated by an obvious graphical method. The curves bring out some points of interest, and give rise to an apparently new paradox expressing the happenings which would result from Einstein's formula if anything other than light could be made to move with the speed of light.

G. W. DE T.

1004. *Relativity Theories of Lorentz and of Mie.* **L. Bloch.** (Comptes Rendus, 171. pp. 1379–1380, Dec. 27, 1920.)—The characteristic of the Mie-Hilbert theory is that the form of δL, the total action variation, is known explicitly, but not that of L, which appears as undetermined in the tensions T^a_b. The Fokker-Lorentz theory, on the other hand, is generally represented as less general, but free from this indetermination. The equation of the gravitation field are given by Fokker [Abs. 1339 (1917)] as $G_{ab} - \frac{1}{2}g_{ab}G = -\kappa(T_{ab} + E_{ab})$, the left-hand member of which is a tensor with generalised divergence essentially zero, so that div. $(T^a_b + E^a_b) = 0$. But Fokker shows, in the same paper, that from the general laws of energy conservation, the latter expression has the value h_a, where h is the force, a result formally incompatible with his former equation. The latter appears correct when T_{ab} and E_{ab} have the meanings ascribed to them by Fokker, so that the first equation must be incorrect. Now these are obtained on the assumption that the electrostatic variation is zero, which would therefore appear unjustifiable, and that a term arising from this integral should appear in the variation with respect to g_{ab} of the total action. And these corrections make the Fokker-Lorentz theory identical with the Mie-Hilbert theory. G. W. DE T.

1005. *Structure of the Helium Atom;* **I. Langmuir.** (Phys. Rev. 17. pp. 339–353, March, 1921.)—*Models for the Helium Atom.*—(1) *Bohr's model* is unsatisfactory because it gives too great a value for the ionising potential and is not in accord with the optical and magnetic properties of helium. Now the chemical evidence suggests that each electron in an atom has its own separate orbit, and that these orbits are closely interrelated. Accordingly two new models are considered. (2) In the *double circle model* the two electrons are assumed to move in two separate, parallel, circular orbits. The model, however, is unstable, for the ionising potential, computed by applying the quantum theory, comes out negative. Another objection is that the magnetic moment is not zero. (3) In the *semicircular model* each electron is assumed to oscillate back and forth along an approximately semicircular path in accord with classical mechanics, each being brought to rest at the end of its path by the repulsion of the other. Assuming the max. angular momentum of each equal to $h/2\pi$, the absolute dimensions of the model were computed. The total energy comes out less than for the Bohr model, and the ionising potential, 25·62 volts, agrees closely with the experimental value. The magnetic moment is zero.

Application of the Quantum Theory to Coupled Electrons.—The success of the semicircular model in giving the correct value for the ionising potential of He suggests that in the case of coupled electrons the quantum theory should be applied not to the momentum of the individual electrons according to the relation $\int p\,dq = h/2\pi$, but rather to the momentum which, by being relayed from one electron to another, passes in each direction around the nucleus. AUTHOR.

1006. *Determination of the Structure of Crystals.* **R. W. G. Wyckoff.** (Frank. Inst., J. 191. pp. 199–230, Feb., 1921.)—A brief survey of recent work on the X-ray analysis of the structure of crystals. The author refers almost entirely to the fundamental work of M. v. Laue, W. H. and W. L. Bragg, and Debye and Scherrer. A. B. W.

1007. "*Brume Sèche.*" **P. Schereschewsky.** (Comptes Rendus, 172. pp. 760–762, March 21, 1921.)—*Brume sèche* [atmospheric obscurity due to causes other than the condensation of water-vapour, *e.g.*, dust or smoke], is of two types, that of fine weather, not very intense, and that which necessitates artificial illumination by day. The latter may be dangerous to aviation and is considered in this note. It differs from fog by decreasing in intensity upwards from a maximum near the surface and by extending to much greater heights, apparently of the order of 2 km. Its optical properties are characterised by the transmission of red and absorption of other rays. A fundamental characteristic is its association with and localisation beneath layers or isolated banks of certain types of alto-cumulus, which occur in regions of slight barometric change on the fringe of a more disturbed area, and from which it appears to be falling. M. A. G.

1008. *Einstein's Principle of Relativity and its Bearing upon Physics.* **J. S. Ames.** (Frank. Inst., J. 191. pp. 1–21, Jan., 1921.—Address.)

1009. *Flying over Clouds in Relation to Commercial Aeronautics.* **B. M. Jones.** (Aeronaut. J. pp. 220–249, May, 1920. Paper read before the Roy. Aeronaut. Soc., March, 1920. Monthly Weather Rev. 48. pp. 528–529, Sept., 1920.)—The prevalence of low cloud in the British Isles is a serious handicap to commercial aviation. The author develops the argument that the best way to maintain a commercial service when cloud is continuous and low with bad weather underneath will be to fly above the clouds. This can only be done commercially with a large-scale organisation and certain additional apparatus, but given these, could be little inferior to fine-weather flying. On the other hand under-cloud flying is possible commercially by individual effort, but at great disadvantage. The difficulties of under-cloud flying are discussed fully under six headings, namely; (1) strain to pilot; (2) danger of collision; (3) discomfort to passengers and pilots; (4) loss of power to use favourable winds; (5) annoyance to people on ground; (6) danger in forced landings. The difficulties of over-cloud flying are dealt with under the seven headings; (1) difficulty of actual in-cloud flying; (2) danger that clouds may come to ground whilst aeroplane is in or above them; (3) difficulty of navigation; (4) difficulty of aerodrome-finding at end of flight; (5) danger of collision in clouds; (6) possibility of having to reach great heights to clear clouds; (7) danger from storm clouds. This examination shows that the organisation necessary for safe over-cloud commercial flying would fall under, (*a*) *metrological*: continuous determination of wind above clouds, height of top of clouds, etc.; (*b*) *constructional*: in laying down wireless control stations along routes; (*c*) *instrumental and training*: in provision of instruments for cloud flying and dead reckoning and training pilots in their use. It is emphasised that the attainment of this is mainly a question of extensive organisation of existing resources. A long discussion followed the paper, the general opinion, as summarised by the author, being that over-cloud flying would be of great value to commercial aviation; that such routine flying is not possible with present facilities; and that it could probably be made safe by suitable organisation. General agreement was not reached as to the exact nature of the organisation and instruments necessary. M. A. G.

1010. *Luminous Night Skies and Clouds.* **A. G. Cook.** (Observatory, 44. pp. 50–52, Feb. 1921.)—Suggests that the phenomena of luminosity of the sky at night may be due to ice crystals such as produce haloes.

In addition to reflecting starlight such ice-crystals may be phosphorescent or luminescent, as has been observed by Maurer on the Swiss glaciers. Some observations of sky effects at night are included. M. A. G.

1011. *Dependence of Wind Speed upon Altitude.* **V. Laska** (Meteorolog. Zeits. 35. pp. 315–316, Nov.–Dec., 1918. Monthly Weather Rev. 47. pp. 707–708, Oct., 1919. Abstract.)—Gives a formula for the dependence of wind speed on altitude, namely: $\log \nu_x = \log \nu_1[1 + (x - 1)/10]$, in which $h = 2^x$, $h < 500$ metres. Here ν is the wind speed in m. per sec., and h the height above the ground in metres. Calculated and observed values compare as follows:—

h	2	4	8	16	32	64	128	256	512
ν Calculated	3·4	3·9	4·4	4·9	5·6	6·3	7·1	8·0	9·1
ν Observed	3·3	—	—	4·7	5·4	—	7·0	8·3	9·1

M. A. G.

1012. *Clash of the Trades in the Pacific.* **C. E. P. Brooks** and **H. W. Braby.** (Roy. Meteorolog. Soc., J. 47. pp. 1–14, Jan., 1921.)—This paper brings into prominence the convergence of air currents associated with the production of the equatorial rains in the Pacific. The regions east and west of the 180° meridian have to be considered separately. In the first the N.E. and S.E. Trades are found to converge at a small angle and evidence is produced that the N.E. Trade is in general colder than the S.E., from which it is concluded that the latter rises over the former, producing rain. In this case the rain would generally reach the surface with a N.E. wind, which is an observed fact. Occasional squalls and rain with a W. wind at the surface are explained by the lateral spreading of the N.E. Trade as it undercuts the S.E. Conditions in the other region are more complex. The Trades meet at right angles, but no marked temperature difference can be traced. Here rain is more widespread, but is most frequent with westerly winds which occur for long periods and being colder are thought to undercut both Trades. The pressure distribution is studied from such island observations as are available, and the control of wet and dry periods appears to rest with a low-pressure area which varies in position. During a dry spell it is situated far west, but a movement eastward to a position near Ocean Island occasions westerly winds, blowing into it, and, as above indicated, a wet spell. Its influence appears to extend throughout the whole equatorial Pacific. M. A. G.

1013. *Underground Water and Meteorological Factors.* **P. Ototzky.** (Roy. Meteorolog. Soc., J. 47. pp. 47–54, Jan., 1921.)—A summary of the author's extensive practical researches both in the laboratory and under natural conditions. The outstanding conclusion is that the variations in the level of the water in a well cannot be identified with those of the underground water-level, but that the regime differs. A well acts as a manometer; for example, the immediate rise in the well level in response to precipitation is due to an increase in the hydrostatic pressure of underground gases caused mainly by the direct weight of precipitated water and transmitted by the underground water, of which the level is somewhat depressed. The investigation embraces the effect of air and soil temperature, barometric pressure, thawing of snow cover, and precipitation on underground and well water-level. It is part of a more extensive inquiry in which factors other than meteorological are considered, *e.g.*, influence of forests, vegetable transpiration, geological factors, etc. M. A. G.

1014. *Rapid Filling up of a Depression.* **Delcambre.** (Comptes Rendus, 172. pp. 701–703, March 14, 1921.)—G. Guilbert has already described the success of his method in forecasting the filling up *in situ* of the depression which arrived off the extreme west of Brittany on 5th Feb., 1921 [see Abs. 783 (1921)]. The present author cites this as an instance of the success of another method which consists in the study of a meteorological entity termed a *noyau des variations barométriques.* A region where in a given interval of time N, the net change of barometric pressure is a rise, constitutes a positive "noyau"; a decrease, a negative "noyau." Conclusions of value in forecasting can be drawn from the movement and development of these systems and from a comparison of those corresponding to N = 3 hours (termed *noyau des tendances barométriques*), with those for longer intervals. An advantage claimed is that a reasonable estimate can be given of the magnitude of forthcoming barometric changes. M. A. G.

1015. *Simultaneous Oscillations of Temperature and Wind at the Summit of the Eiffel Tower.* **R. Dongier.** (Comptes Rendus, 172. pp. 699–701, March 14, 1921.)—The records from the summit of the Eiffel Tower have on numerous occasions shown simultaneous oscillations of temperature and wind with no marked change of pressure; the variations of temperature amount to several degrees in a few minutes, as in squalls, but differ from the latter by being repeated at intervals, in opposite directions. Two such occasions are described in detail and the records of wind and temperature reproduced. There is evidence of the existence in such cases of a surface of discontinuity with warm air above and a distinct cold current below, and fluctuations in its level are supposed responsible for the variations of temperature and wind at the summit of the Eiffel Tower, which is alternately in the warm and the cold current. The "steering surface" (Bjerknes) which in the front of a moving depression marks the limit of the "warm sector" may be indicated in this way by the Eiffel Tower records. M. A. G.

1016. *Irregular Atmospheric Refraction at High Levels.* **E. R. Miller.** (Monthly Weather Rev. 48. pp. 509–511, Sept., 1920.)—During pilot-balloon work at Madison (Wisconsin) it has often been observed on clear fine days that the balloon, as seen through the theodolite, suddenly becomes faint and sometimes, though less frequently, distorted, while at times its complete disappearance is unusually sudden. Particulars of some cases have been collected in which the balloon was followed for some time after becoming faint or distorted, and it is found that this occurred shortly after the passage of the balloon through a surface of velocity-discontinuity. Corresponding temperature records are not available, but it is thought that it is a refraction effect. Reasons are given against supposing that the observed increase in velocity and partial extinction of the balloon are due to leaking, or the distortion to eye-strain or internal reflections in the theodolite. M. A. G.

1017. *Further Uses of the Climograph.* **B. M. Varney.** (Monthly Weather Rev. 48. pp. 495–497, Sept., 1920.)—The author's purpose is to emphasise the possibilities of the climograph as a means of representing climatic conditions graphically and as an aid to visualising the effects of these conditions on human affairs. He chooses air temperature and relative humidity as the elements whose joint effect it is desired to represent, and considers this a better combination than the wet-bulb temperature and relative humidity as used by Griffith Taylor in his development of the method. The limitation to two variables is a disadvantage since the effect of wind should be considered at the same time. Data for San Francisco (coastal climate) and Fresno, California (continental), are employed to illustrate the application not only to the representation of the seasonal variation of climatic conditions, but also of the normal diurnal variations of condition affecting organic life and of the seasonal variation of the conditions at a particular time of day. The application to non-periodic changes is suggested and illustrated in the case of a hot wave, while a number of other possibilities are indicated. M. A. G.

1018. *Oceanic Density.* **J. Thoulet.** (Comptes Rendus, 172. pp. 861–863, April 4, 1921.)—This paper draws attention to the importance of determining the density of sea water immediately under its conditions of temperature and salinity. From the standpoint of oceanic circulation this figure is more important than the normal density. A rapid method for determining density is suggested. It consists in measuring the refractive index at once with a refractometer, and deducing the density graphically or from tables. This method is claimed to give the result correct to one or two units in the fourth decimal place, and has the advantage that very little of the sample is required. W. A. R.

1019. *Refractive Index and Density of Sea Water.* **C. Vaurabourg.** (Comptes Rendus, 172. pp. 863–865, April 4, 1921.)—This paper gives the results of investigations on the determination of oceanic density by the measurement of refractive index, as suggested by Thoulet [see preceding Abs.]. For a given sample the variation of the index is more feeble by 2½ times than the corresponding variation in density. At constant temperature the variation of index is one-fourth of the corresponding variation in density. A formula is given for the calculation of the density given the index, and the method is shown to be comparable in accuracy to the best methods at present in use. W. A. R.

1020. *Application of Stereoscopic Vision to the Registration of Glacial Variations.* **P. L. Mercanton.** (Comptes Rendus, 172. pp. 582–583, March 7, 1921.)—It is not always possible to place "marks of advancement" in the front of a glacier. This requires usually a good deal of trouble and time and may be dangerous. Often also the disposition of the bed does not lend itself to setting up the necessary fixed stations for the usual methods of registering advance. Glacial variations may not always be shown by displacements of the front but are often local variations in its shape; the amplitude of these variations is too small to be immediately apparent and yet they are quite important. The direct comparison of photographs is not always sufficient to show this. The method now suggested is as follows: At the same station and with the same dark slide take two photographs of the front, preferably in an azimuth normal to the presumed direction of variation, and at the interval of time desired. Afterwards on examining the two proofs stereoscopically the modified regions of the glacier will be seen to stand out in relief upon the parts of the image corresponding to the immovable object such as sky, rocks, etc. The precautions necessary are stated and it is noted that the results obtained are only qualitative. The author has verified the applicability of the method to the d'Orny glacier. A. E. G.

1021. *Unusual Lunar Halo Phenomenon.* **E. W. Woolard.** (Monthly Weather Rev. 48. pp. 511–512, Sept., 1920.)—The phenomenon was observed by A. A. Graham about 8 p.m. on 20th Sept. 1920, 90th meridian time, at Topeka (Kansas) and consisted of a halo surrounding the moon, with a tangent arc on the east side of greater radius and concave outwards. The point of tangency was at the same elevation as the moon. No prismatic colours were observed, and the sky was to all appearances clear. M. A. G.

1022. *Tides in the Straits of Dover.* **G. R. Goldsbrough.** (Univ. of Durham Phil. Soc., Proc. 6. 1. pp. 22–30, 1915–1920.)—The sea bordering the Straits of Dover can be divided into two areas. In the one the whole body of water moves eastward when the tide is rising at Dover; in the other the water moves south-westward during a rising tide, and *vice versa*. Between these two areas is the Strait, and the effect of the oscillating area on each side is to produce a more complicated motion in the Strait. There is a definite no-current line, or a line of junction of the tides, which moves from the western to the eastern boundary. Beechy's observations show that there is no transverse motion in the Channel and that it can all be taken as longitudinal. An analysis of the long waves formed in a canal of slowly varying section, shows that this definiteness of motion is due to the constriction of the Channel at Dover—the explanation usually offered. W. A. R.

1023. *Infra-Red Spectrum of the Sun,* λ8900–λ9900. **F. S. Brackett.** (Mt. Wilson Observat. Contrib. No. 197. Astrophys. J. 53. pp. 121–132, March, 1921.)—*Photography of Infra-Red Spectra to* λ9900.—In previous work scattered light has been a serious obstacle to the extension of observations into the infra-red. By using a monochrometer with the second slit removed the author *eliminated scattered light* and obtained, on plates sensitised with dicyanin, spectrograms of even intensity which show fine structure to λ9850. This limit seems to be fixed in astronomical work by Langley's broad atmospheric absorption band ϕ. Below λ9400 a *water solution of malachite green* is recommended as a *screen* since it is almost opaque to wave-lengths shorter than λ7200.

Infra-Red Solar Spectrum λ8900 *to* λ9900.—Spectrograms made in the first order of a 15-ft. concave grating mounted in the constant-temperature pit of the Mount Wilson laboratory gave the *wave-lengths* of 563 lines to about 0·01 Å., at least as far as λ9650. To determine the *origin* of the lines, solar-rotation photographs were made with the 13-ft. spectrograph of the 60-ft. tower telescope, and spectrograms taken under conditions of low and high humidity were compared. It was found that 45 and possibly 70 lines, including one-fifth of the fainter lines observed, are of solar origin, while 60 of the stronger diffuse telluric lines broaden remarkably as the humidity increases and hence undoubtedly form an *absorption band due to water-vapour between* $\lambda 9300$ *and* $\lambda 9650$. Of the solar lines, 14 are attributed to *iron* and 1 or 2 to *nickel*. AUTHOR.

1024. *Pressure in Mg Layer of Sun's Atmosphere, and Verification of Principle of Relativity.* **A. Perot.** (Comptes Rendus, 172. pp. 578–581, March 7, 1921.)—Low pressure indicated for cyanogen bands [see Abs. 1555 (1920)] was not definitely proved, so the author turns to earlier work on the various *b*-rays of Mg [see Abs. 1099 (1911)], and finds the pressure coefficient of b_1 about half as large again as that of b_2. Taking the ratio as definite, he claims to have established a method of inferring the pressure in the solar atmosphere. To the difference previously measured between solar b_2 and arc b_2 at atmospheric pressure, $1 \cdot 16 \times 10^{-6}$, he now adds $1 \cdot 35 \times 10^{-6}$ for the difference between atmospheric pressure and a practical vacuum; obtaining $2 \cdot 5 \times 10^{-6}$, which is in reasonable agreement with Einstein's 2×10^{-6}.

His measures of wave-length in the arc of the three *b* lines are, in Å. units: $\lambda b_1 = 5183 \cdot 614$; $\lambda b_2 = 5172 \cdot 690$; $\lambda b_4 = 5167 \cdot 340$.

W. W. B.

1025. *Use of Geocentric Latitudes to Facilitate Identification of Asteroids.* **L. Fabry.** (Comptes Rendus, 172. pp. 27–31, Jan. 3, 1921.)—Taking as his text the announcement of photographic observations from Algiers of two asteroids not then identified, the author points out the difficulty of extrapolating a month after the period of computed ephemerides. He suggests that the geocentric latitude provides an easier method, and applying it to the two asteroids quoted, identifies them with (57) Mnemosyne and (167) Urda respectively. W. W. B.

1026. *Theories of Formation of New Stars.* **A. Véronnet.** (Comptes Rendus, 172. pp. 666–669, March 14, 1921.)—Dealing first with the theory of a collision between stars, the author finds the most plausible figures when the masses are unequal, such as those of the sun and Jupiter, but considers the probability of such a collision ten thousand times too small to account for the number of novæ. Next he takes the theory of a star rushing into a nebula, and considers the effect of different dimensions of the nebula. He gives numerical values for the increase of brightness and the duration of the increase, and on the assumption of parabolic motion obtains the period from one plunge into the nebula to the next, and considers that only the final catastrophe, when the star becomes absorbed in the nebula, corresponds to the outburst of a nova. He objects to this theory on the ground that nebulæ must be 100 times as numerous as stars to account for the frequency of novæ. He then proceeds to suggest that a nova, or recrudescent star, results from the fusion of a close binary. Considerations of energy lead to the view that a mass rather greater than Jupiter, becoming fused to the sun would produce the phenomena of a bright nova, and the circulation of the molecules and electrons will account for the bright lines of the spectrum. Radiation-pressure will in the course of a year provide a nebulous envelope, so that the nova will appear as a nebulous star. The author gives probable dimensions for such an object, with a real diameter 60,000 times the radius of the earth's orbit, at a distance of 1000 parsecs. W. W. B.

1027. *Radiation-Pressure and Celestial Motions.* **H. N. Russell.** (Astrophys. J. 53. pp. 1–12, Jan., 1921.)—*Radial Velocities of Nebulæ.*—*Various suggested explanations* are shown to be inadequate. (1) The maximum *radiation-pressure due to the galaxy* as a whole is probably less than 2×10^{-13} dyne/cm.^{2}. After deriving an expression for the acceleration which this could produce in a spiral nebula of a given apparent diameter, parallax and spectroscopic rotation, it is shown that even on the most favourable assumptions the acceleration of the Andromeda nebula cannot exceed $1 \cdot 1 \times 10^{-10}$ cm./sec.^{2}, or that of N.G.C. 4594, $1 \cdot 5 \times 10^{-13}$cm./sec.^{2}. (2) The *gravitational attraction of the galaxy* upon these nebulæ is probably much greater than the repulsion due to radiation, but it is nevertheless too small to account for their observed radial velocities. (3) An *electrostatic repulsion,* if sufficient to neutralise gravitational attraction, would cause the disruption of the bodies. In fact pressure of any sort could not sensibly alter the motion of a spiral nebula without seriously deforming it.

Radiation-pressure between binary stars must even in extreme cases be less than one ten-thousandth of the gravitational attraction, and is probably much smaller. [See Abs. 334 (1920).] AUTHOR.

1028. *Stellar Atmospheres. Stars showing an Upper Layer comparable with the Sun.* **H. Deslandres** and **Burson.** (Comptes Rendus, 172. pp. 729–730, March 21, 1921.)—Continuing research into stars showing bright H_2 and K_2 [see Abs. 802 (1921)], the authors have found a second star of type G (ε Geminorum) and one of type Ma (α Orionis), which not only show bright H_2 and K_2 but also dark H_3 and K_3 in the centre of H_2 and K_2, belonging to the upper stratum of their atmospheres. Enlarging the negatives obtained with small dispersion in the prismatic camera, to make them comparable with solar spectrograms from the great spectroheliograph, the H_3 and K_3 rays of these stars appear five times as broad as those in the sun, from which they infer in the upper atmosphere of the stars either a greater density or a more intense electrification. Full details will follow later. W. W. B.

1029. *Parallaxes of 1646 Stars derived by the Spectroscopic Method.* **W. S. Adams, A. H. Joy, G. Strömberg,** and **C. G. Burwell.** (Mt. Wilson Observat. Contrib. No. 199. Astrophys. J. 53. pp. 13–84, Jan., 1921.)—*Spectroscopic Method of Determining Absolute Magnitude and Parallax.*—Some years ago it was discovered that there is a correlation between the relative intensities of certain spectral lines and absolute magnitude for stars of the more advanced spectral types. In the past three years numerous new trigonometric parallaxes have become available and have enabled this correlation to be established more accurately. For the stars for which trigonometric parallaxes have been determined the absolute magnitudes have been computed directly, but for the Cepheid variables the parallactic motion has been used, and in the case of the giant M stars a combination of results derived from peculiar motion and trigonometric parallaxes. The formulæ employed are shown in the paper. The absolute magnitudes obtained in this way have been plotted against the relative intensities of certain pairs of lines and from the resulting curves reduction tables have been constructed for each observer. These curves are continuous except in the case of stars of the late K and M types where the division into giants and dwarfs introduces a marked discontinuity. The absolute magnitudes and parallaxes derived by means of these tables are found to have probable errors of ± 0·4 mag. and ± 20 % respectively. The method used in classifying the spectra and in estimating the intensities of the spectral lines is described.

Absolute Magnitudes and Spectroscopic Parallaxes of 1646 *Stars*, including revised values for 495 stars contained in the 1917 list.—An extensive table gives the Boss or Cincinnati number, the name and position of each star, the Harvard visual magnitude, total proper motion, spectral type, absolute magnitude, and spectroscopic parallax. The trigonometrical parallax is given, if known. AUTHORS.

1030. *A Photoelectric Study of Algol.* **J. Stebbins.** (Astrophys. J. 53. pp. 105–120, March, 1921.)—Observations during 1919–1920 with a photoelectric photometer give a new *light-curve* for this star which is considerably more accurate than the curve obtained in 1909–1910 with the selenium photometer [see Abs. 203 (1911)]. Besides confirming the secondary minimum and the continuous variation between minima, the new results show an effect due to the ellipsoidal shape of the components of the system. The phase of the secondary minimum indicates that there can be no rapid motion of the line of apsides of an elliptical orbit ; in fact all of the photometric evidence points to a circular orbit. Corrections to the ephemeris for the times of minimum are given. Neglecting the light of the third body the *elements of the eclipsing binary system* are derived, but it is pointed out that definitive values of the elements cannot be found until measures of the spectrum and magnitude of the third component and a very accurate parallax for Algol are available. The elements found agree closely with those obtained in 1909–1910. Certain differences suggest a *colour-index for the satellite* which would make it somewhat yellower than the primary.

Constancy of Three Comparison Stars.—The star δ *Persei* is suspected of variation to the extent of 0·04 or 0·05 mag., but *l* and π *Persei* were found to be constant within 0·01 mag.

Photoelectric Photometer for Stars.—*The precision* which may be reached is indicated. AUTHOR.

1031. *Provisional Elements of the Eclipsing System RS Canum Venaticorum.* **B. W. Sitterly.** (Astrophys. J. 53. pp. 99–104, Jan., 1921.) —*Eclipsing Binary RS Canum Venaticorum.*—*Provisional elements* for this system, B.D. + 36°·2344, have been computed on the basis of a series of observations made by Maggini in 1916. The light-curve shows extremely long minima which together take four-ninths of the whole period. The two giant stars apparently touch at periastron ; they are elongated toward each other, and move in an orbit with an eccentricity of 0·17. The eclipses are either total or annular. The probable distance is 1200 light-years. AUTHOR.

1032. *Spectroscopic Orbit of the Cepheid Variable X Cygni.* **J. C. Duncan.** (Mt. Wilson Observat. Contrib. No. 196. Astrophys. J. 53. pp. 95–98, Jan., 1921.)—*Cepheid Variable X Cygni.*—A brief summary of previous observations relating to this variable is given. From 23 spectrograms made at Mount Wilson with the 60-in. reflector and single-prism spectrograph, the *elements of the spectroscopic orbit* have been computed. The values of K (28 km./sec.), of *a* sin *i* (6,121,000 km.), and of the mass-function (0·034) are remarkably large. The probable error for a plate is large in comparison with the deviations in the measures of a single plate made by different observers; but there is no evidence of a secondary oscillation. AUTHOR.

1033. *Orbit of the Short-period Spectroscopic Binary 65 τ Cygni.* **J. S. Paraskévopoulos.** (Astrophys. J. 53. pp. 144–149, March, 1921.)—*Spectroscopic Binary Components of the Triple System 65 τ Cygni.*—This interesting system is a visual binary whose brighter component is a spectroscopic binary. During 1920 several continuous series of spectrograms obtained with the Bruce spectrograph of the Yerkes Observatory enabled the *elements of the orbit* to be computed. The period is only 3h. 25m. 4s., the shortest yet known, and *a* sin *i* is only 14,924 km. Taking the parallax of the system as 0·031″, the distance apart of the components comes out about 1,600,000 km. But from the brightness of the brighter component, absolute magnitude about 1·5, its diameter is probably about 9,000,000 km. Apparently, then, the separation of the components is less than the diameter of one of them. But neither the hypothesis of a pear-shaped body nor that of a pulsating star seems to explain the facts satisfactorily. AUTHOR.

1034. *Elements of the Eclipsing System SX Cassiopeiæ.* **M. Fowler.** (Princeton Univ. Obs., Contrib. No. 3. Astrophys. J. 53. pp. 165–167, March, 1921.)—From the normals obtained from the later (1915) observations of Luizet, the *elements of the system* have been computed. The *light-curve* at the minima is given and also a *picture of the system.* The stars are both giants with radii about 13 and 10, and brightness about 100 and 24, respectively, in terms of the sun. The primary eclipse is annular, the secondary total. AUTHOR.

1035. *Geometrical Classification of Long-Period Variables.* **J. G. Hagen.** (Astrophys. J. 53. pp. 179–184, April, 1921.)—The author gives a table of the *constants of the light-curves* of 66 variables as determined by harmonic analysis, and shows that on the basis of these constants the variables fall into three groups which coincide with the three main classes given in the Harvard Annals for 1907: (1) with uniform variation, (2) with broad minima, and (3) with a rapid increase. The first group corresponds in general to Phillips' Group I, and the last two are subdivisions of his Group II. AUTHOR.

1036. *Periodic Changes in the Emission Lines of Spectra of Class Md Variable Stars.* **P. W. Merrill.** (Mt. Wilson Observat. Contrib. No. 200. Astrophys. J. 53. pp. 185–200, April, 1921.)—*R Leonis, R Hydræ, R Serpentis, X Ophiuchi, χ Cygni, and T Cephei* have been observed spectroscopically over a considerable part of their light periods, from two to twelve spectrograms having been made of each. The intensities of H_δ, H_γ, λ4202 Fe, λ4308 Fe, λ4571 Mg, and some other bright lines at the different phases are recorded. A compilation and discussion of past and present data referring to these lines shows that they appear after light minimum, in the order mentioned, in every long-period variable of Class Md whose spectrum has been adequately observed, and exhibit substantially the same remarkable behaviour as in the type star ο Ceti. There is strong evidence, therefore, that these spectral variations are characteristic of stars of this class. *The changes in relative intensity of the lines of the Balmer series of hydrogen and also of certain iron lines* are particularly interesting. A discussion of the physical interpretation of these variations is reserved until more data are available. AUTHOR.

1037. *On the Passage of a Star through a Nebula.* **E. W. Brown.** (Astrophys. J. 53. pp. 169–178, April, 1921.)—*Theory.*—Neglecting the effects of mutual collisions between the particles of the nebula when the swarm is undisturbed as well as the gravitational attraction of the swarm on its constituents, the author derives the formulæ for the hyperbolic motion of the particles and shows that all those originally at a distance b from the path of the star will cross that path at the same point at a distance $b^2/2a$ behind the star, where a is the ratio of the mass of the star to the square of its speed, V^2. If we suppose that as a result of this focusing action collisions occur along the path of the star, these might produce a gaseous appendage of conical form with an angle β such that $\sin \beta$ is equal to the ratio of the mean velocity of the gas molecules to V.

Variable Nebula N.G.C. 2261 (*Hubble*), *with Fan-shaped Appendage.*—The above theory suggests an *explanation* of the form of the appendage, and certain numerical consequences as to the mass, scale of magnitude, distance, and life of this object are deduced. AUTHOR.

1038. *Orbits of Seven Spectroscopic Binaries.* **R. F. Sanford.** (Mt. Wilson Observat. Contrib. No. 201. Astrophys. J. 53. pp. 201–223, April, 1921.)—*Seven Spectroscopic Binaries: Boss* 373, $O\Sigma$ 82, *Lalande* 29330, *Companion* to *α Herculis*, 205 *Draconis*, *Boss* 5591, *Lalande* 46867.—*The elements of the orbits* have been derived from 15 to 30 spectrograms of each, most of them made with an 18-in. camera and the 60-in. or 100-in. reflector. In the case of the first, fifth, and sixth binaries, both components were measured. The periods are each about 4 days except for the fourth and seventh, which are 51·6 and 6·72 days respectively. Radial-velocity diagrams are given. The *spectroscopic parallax, proper motion, and absolute magnitude* of each, as furnished by Adams and Joy, are also given. Lalande 29330 and 46867 are particularly interesting because of low luminosity, + 6, and late spectral class, K. Lalande 46867 is very similar in spectroscopic peculiarities to σ Geminorum.

α Herculis and Companion.—The *radial velocity* of the centre of mass of the companion is − 37·2 km./sec., whereas that of α Herculis is − 32·2 km./sec.; and from the parallax they are separated at least 250 astronomical units. These facts indicate that they probably form merely *an optical pair.*

Probable Eclipsing Variable Star.—The data for 205 *Draconis* suggest that it would be a favourable case to examine for variability caused by eclipse. Its magnitude is 7·2 and spectral class F2. AUTHOR.

1039. *Radiative Equilibrium and Spectral Distribution.* **E. A. Milne.** (Roy. Astron. Soc., M.N. 81. pp. 375–388, March, 1921.)—The author works out a theoretical spectral distribution for a star in radiative equilibrium and compares its curve with that of Planck's, for a black body giving the same total radiation. He finds his theoretical curve almost exactly similar to the other, but displaced towards the violet, and concludes that "we may expect the apparent temperature deduced from the total radiation to be 3·1 % smaller than that deduced from an application of the usual form of Wien's law." This accounts for half of the 6 % discordance found in the case of the sun, for which Abbot deduced 6230° from the wave-length of max. energy for the whole disc, but only 5860° from the solar constant. The solar spectrum, however, markedly differs from a black-body spectrum, so that too much reliance must not be placed on this argument. Comparing his theoretical distribution with Abbot's observations of variation of colour and temperature over the sun's disc, the author finds considerable discordances, in relation to which he discusses various explanations, such as scattering.

W. W. B.

1040. *Period-Eccentricity Relation in Binary Systems.* **R. E. Wilson.** (Astron. J. 33. pp. 147–150, May 5, 1921.)—Of the 253 orbits available, the author excludes the 18 Cepheid variables. Of the remainder, Algol and κ Pegasi are triple systems in which two values each of period and eccentricity are available; 151 are spectroscopic systems. The grouping adopted is 0 to 4 days, 4 to 8 days, 8 to 25 days, 25 to 100 days, 100 days to 5 years, 5 to 50 years, 50 to 100 years, 100 to 200 years and above 200 years; and these are sub-divided separately into Type I and Type II, and into giants and dwarfs. A maximum eccentricity is shown for the group 25 to 100 days, followed by a minimum for the next group. In spectroscopic binaries with periods from 8 days to 5 years, the period-eccentricity curve for those whose principal star is of Type I, differs considerably from the Type II group. The giant stars show a more pronounced maximum and minimum than the curve for all the stars. Another tabulation gives the mean amplitudes of velocity variation, orbital velocities of the spectroscopic binaries for the various period-groups and spectral types. This shows not only a decrease of velocity in orbit with type, but also a decrease in orbital velocity with period. The author's conclusion after analysis is that the relatively rapid increase in eccentricity in the first four period-groups is due almost wholly to the predominance of giant systems in these groups, so that an increase in the number of dwarfs would tend to reduce the apparent maximum in groups 3 and 4; also that the minimum groups 5 and 6 is due partly to the systematically low eccentricities of the dwarf stars in these groups and partly to the greater probability of the discovery of the less eccentric orbits among the long-period spectroscopic binaries. Thus an increase in the number of discoveries may tend to reduce the discordance from a uniform curve.

W. W. B.

LIGHT.

1041. *New Nephelometer.* **C. Cheneveau and R. Audubert.** (J. de Physique et le Radium, 2. pp. 19–23, Jan., 1921.)—In a previous paper [Abs. 1411 (1920)] the authors have established that for heterogeneous turbid media (*e.g.*, fine precipitates, emulsions of gum, mastic, oil, etc.), the mass M of the particles in suspension is related to the ratio I/I_0, where I is the intensity of the light transmitted by the turbid medium and I_0 the intensity of the initial incident light, by a simple exponential expression, $I/I_0 = 1 - e^{-B/M\beta}$, B and β being two coefficients which depend only on the nature of the suspended particles and on the wave-length of the light utilised. The authors now show that the determination of I/I_0, in monochromatic light, allows of the evaluation of the total mass of the particles in a turbid medium. Different experimenters, including Richards and Wilson, have attempted to evaluate the difference of the concentrations in two suspensions, by a comparison of the intensities of the light which they diffuse. These methods, termed nephelemetric, appear incorrect to the authors, except for very fine suspensions where the value of n in Rayleigh's formula, $I/I_0 = 1 - e^{-A/\lambda^n}$, is approximately equal to 4. In other cases it is shown that the exponent n of the wave-length varies with the concentration. The spacimeter of Vlès, Watteville, and Lambert is referred to, and a new nephelometer of simple design is then described which is based on the connection between the absorption of a turbid medium and its concentration. The absorption of the turbid medium is compensated by that of a prism of very small angle made of a neutral-coloured glass. The latter has been employed in the spectrograph of Mees and in Féry's spectrophotometer. A detailed description with diagrams is given of the new apparatus. Experiments have been made with aqueous mastic emulsions and fine suspensions of precipitated barium sulphate in water, and the above exponential law has been confirmed. The apparatus is found to possess an accuracy of 2–5 %, and may be used for numerous purposes, such as the study of reaction velocities, formation of precipitates, etc. H. H. Ho.

1042. *Projection Apparatus.* **Dussaud.** (Comptes Rendus, 172. pp. 808–809, March 29, 1921.)—A brief description is given of an apparatus for projecting images on a screen of any object. A system of reflectors is arranged behind the condensing lenses to give an illumination as strong as possible. Using a half-watt lamp taking 3 amps. at 110 volts, good results were obtained in a light room, a screen 3 m. square being employed. A. W.

1043. *Reflection and Transmission Ratios by the Ulbricht Sphere.* **E. Karrer.** (Optical Soc. of America, J. 5. pp. 96–120, Jan., 1921.)—Gives a short description of the methods which have been employed for the measurement of the reflection and transmission ratios of surfaces by diffused light. Twelve such methods are described and the arrangement adopted by Nutting to simulate an infinite plane is discussed in detail. The method employed by the author depends on the use of a small sphere of which the test surface forms a small portion of the area. The sphere is illuminated by a battery lamp, and the brightness of the test surface is compared with that of the neighbouring surface of the sphere by means of a Martens polarisation photometer. Magnesium carbonate is thus found to have a reflection ratio, in diffused light, of 98 to 99 %.

New Transmissometer.—An apparatus for the absolute measurement of transmission ratio (termed a transmissometer) consisting of two spheres placed side by side with the test surface as a common surface for both, is described in the latter part of the paper. J. W. T. W.

1044. *The Colours of Mixed Plates.* I. **C. V. Raman** and **B. Banerji.** (Phil. Mag. 41. pp. 338–347, March, 1921.)—As the paper is mainly descriptive and hence unsuitable for abbreviation, it is only possible to indicate by title the various phenomena observed, as follows :—Diffraction haloes due to a mixed plate ; Haloes due to obliquely-held plates ; Films containing distorted boundaries ; Effect of drying of an albumen film ; Non-uniform films. L. H. W.

1045. *Reflection of Radiation from an Infinite Series of Equally Spaced Planes.* **K. W. Lamson.** (Phys. Rev. 17. pp. 624–625, May, 1921.)—If the fractions of the incident radiation upon any plane which are absorbed, reflected, and transmitted by that plane are constant and denoted by a, r, and t respectively, and if all possible internal reflections are taken account of, the *coefficient of reflection* is shown to equal $(1/2r)\left\{1 - t^2 - r^2 - \sqrt{[1 - 2t^2 - r^2 + (t^2 - r^2)^2]}\right\}$. When both a and r are very small, as in the case of the *reflection of X-rays from a crystal surface*, the expression becomes $[1 + a/r - \sqrt{(a^2/r^2 + 2a/r)}]$; thus the proportion reflected depends only on the ratio of absorption to reflection per plane. AUTHOR.

1046. *Field of View of a Galilean Telescope.* **H. A. Hughes** and **P. F. Everitt.** (Optical Soc., Trans. 22. 1. pp. 15–18 ; Disc., 19, 1920–1921.)—The authors show that if f_2 be the focal length of the negative lens forming the ocular, m the magnification of the system, d the centre of rotation of the eye from the ocular, P the semidiameter of the objective (= entrance pupil), and p the semidiameter of the pupil of the eye, then the total field of view $= Z \tan^{-1} (P + mp)/[(m - 1)f_2 + md]$. L. H. W.

1047. *Visual Fatigue and Eye Strain in the Use of Telescopes.* **R. J. E. Hanson.** (Optical Soc. Trans. 22. 1. pp. 26–27 ; Disc., 28, 1920–1921.)—Visual fatigue is due partly to muscular fatigue when the postures of the body and head are strained, partly to causes specially prominent in monocular vision. To minimise the loss of acuity due to fatigue the author recommends that the following rules should be observed : (1) Avoid mal-orientation of the eyes, head, and spine (this is specially important for the student beginning to use the microscope). (2) If the head must be held in position other than erect, avoid unnecessary strain to the muscles forming the "spinal polygon" by the use of a soft buffer, preferably of sponge rubber, to support the forehead. (3) Protect the non-aligned eye from undue contrast and strain. (4) Always take up a good "stance" either when standing or sitting, so that the body and head are held in the required positions with as little muscular effort as possible. (5) When using heavy instruments which have to be held in front of the eye, as telescopes, sextants, etc., have them fitted with a soft buffer against which the forehead can rest as a *point d'appui*, and let the weight of them be taken by a sling round the neck so that the weight comes directly on the spine and not on the arms. L. H. W.

1048. *The Unaided Eye.* III. **J. W. French.** (Optical Soc., Trans. 21. pp. 127–156, 1919–1920.)—This forms the third part of a general treatise, and deals with the optical capabilities of the eye and theories of vision. [See Abs. 350 (1920).] L. H. W.

1049. *Refractometry of Prisms.* **J. Guild.** (Phys. Soc., Proc. 33. pp. 179–189; Disc., 189, April, 1921.)—A generalised formula for the refraction of light through a prism is obtained, and the particular cases pertaining to practical methods of refractometry deduced from it. The sensitivity of various methods for various prism angles and refractive indices is shown in a series of curves, as is also the liability to error due to errors in auxiliary constants. AUTHOR.

1050. *Fermat's Theorem and the Law of Least Time in Geometrical Optics.* **F. Croze** and **P. Chatelain.** (J. de Physique et le Radium, 1. pp. 178–187, Dec., 1920.)—The authors point out that the optical length of the path of a ray proceeding from a point A to a point A′ is not invariably a minimum or maximum with respect to the optical lengths of the paths infinitely near it and the actual conditions arising in certain practical cases are discussed. **P. Langevin** (*ibid.*, p. 188, Dec., 1920).—P. Langevin gives a geometrical method of demonstrating the theorem discussed by Croze and Chatelain. J. W. T. W.

1051. *Theorem of Geometrical Optics, and its Application to Prism Systems.* **G. Gouy.** (Comptes Rendus, 172. pp. 196–201, Jan. 24, 1921.)—Given the path of a particular beam through an optical system, it is shown that the properties of a beam approximating to the first may be obtained by a simple construction; and this principle is illustrated by applying it to a system of prisms and plane mirrors. A. W.

1052. *Refraction through Prisms. Bravais' Laws.* **G. Laville.** (J. de Physique et le Radium, 2. pp. 62–64, Feb., 1921.)—A simple treatment is given of the refraction of light through a prism not in a principal plane, a vector method being employed. The method adopted leads to an easy verification of the three laws of Bravais. A. W.

1053. *Aplanatic Systems and the Sine Condition; Calculation of Coma.* **G. Gouy.** (Comptes Rendus, 172. pp. 419–423, Feb. 21, 1921.)—Describes a new method of demonstrating that the sine condition is a necessary and sufficient condition for an aplanatic system. The same construction gives the form of the image-forming wave-front when the sine condition is not fulfilled, and shows that the coma depends only on the function which connects sin u_1 and sin u_2. The special case of $u_1 = \frac{1}{2}\pi$ is discussed separately in detail (*ibid.*, pp. 632–636, March 14, and pp. 827–828, April 4, 1921.)—*Calculation of Coma.*—Describes the method of calculating the coma in any given case, when the actual amount of coma present is small. It is pointed out that when coma is present and appreciable a small correcting factor must be applied to one of the formulæ. J. W. T. W.

1054. *Achromatic Triplet of Large Field.* **Pariselle.** (Comptes Rendus, 172. pp. 530–532, Feb. 28, 1921.)—Discusses the conditions which must be fulfilled in the case of an achromatic triplet operating with the largest possible field. If the three focal lengths are f_1, f_2, and f_3 then for all three lenses to have the same aperture it follows that $f_2 = f_1 - a$ and $f_3 = f_2 - 2b$, where a and b are the respective separations. The condition for achromatism gives the additional relation $(f_2 + f_3)(2a - f_1) + 2bf_2 = b(3a - 2f_1) + f_2 f_3$, so that for any given value of f (the focal length of the system) it follows that one further condition can be fulfilled by the five variables at disposal. J. W. T. W.

1055. *Use of Telescopes with Internal Focusing for Stadia Surveying.* **E. O. Henrici.** (Optical Soc., Trans. 22. 1. pp. 20–25, 1920–1921.)—Telescopes with an internal negative focusing lens and with cross-hairs rigidly fixed in the tube carrying the object glass have been introduced of late years for use with surveying instruments. Such telescopes have several advantages; they can be made dust- and damp-tight or even water-tight, and the collimation is less liable to variation during focusing. When an ordinary draw tube is used for focusing it is difficult to make and keep the movement absolutely true so that the cross-hairs remain on the optic axis of the object glass when the tube is moved. With the negative lens the cross-hairs are fixed, and not only can the lens be more easily guided, so that its eccentric movement is small, but also a given eccentric movement has much less displacing effect on the image, relative to the cross-hairs, than an equal movement of the cross-hairs themselves. Such a telescope is equivalent to one having an object glass of varying focal length. In the ordinary telescope $L = kl + f + c$, where L is the distance of the vertical axis of the instrument to the stadia rod, l the intercept of the stadia rod between the cross-hairs, f the focal length of the object glass, c the distance of the object glass in front of the vertical axis, and k a constant. In the case under consideration neither k nor f are constants, and the present paper discusses the effect of this in stadia working. It is shown that the error in assuming that the telescope with internal focusing is anallatic, is generally negligible. A. W.

1056. *Double Refraction and Crystalline Structure of Silica Glass.* **Rayleigh.** (Roy. Soc., Proc. 98. pp. 284–296, Jan. 3, 1921.)—Although glasses in general have no double refraction, except that due to bad annealing, yet silica glass is found to have a doubly refracting structure, which cannot be so accounted for, and must rather be regarded as crystalline. The double refraction is very weak, of the order of 1/60th that of crystalline quartz. In a mass of silica which has been melted, but not drawn or blown, the structure consists of doubly refracting grains, with dimensions of about 1/2 mm., oriented at random. These grains may correspond to the original fragments of quartz which were melted to form the glass, but this is uncertain. The grains are very persistent and individually survive a remelting of the material. If the grained material is drawn out while soft, the grains are elongated into crystalline fibres or ribbons. These fibres always give "straight extinction" in the polariscope, and their length is along one axis of the ellipsoid of optical elasticity, but apparently not always along the same axis. The fact that the crystalline grains can be made to flow in this way assimilates them to Lehmann's *liquid crystals.* If the material is bent or twisted the fibres follow its course unbroken, and are always extinguished in the polariscope if the nicols are set along the tangent and normal to their direction at any point.

Fused silica sometimes contains isolated small inclusions of quartz, with angular outlines, which have escaped vitrification. These are conspicuous in the polariscope by the strain effects they produce in the surrounding glass. Discs of optical "silica," which are built up by a special process, show a very curious grain structure, on which the crystalline grains are superposed. By prolonged heating the crystalline structure was made to disappear, but subsequent heating for about ten minutes caused the structure to reappear to a large extent. A. W.

1057. *Yellow Dyes Transparent to Ultra-Violet Light.* **F. Stumpf.** (Zeits. wiss. Phot. 20. pp. 183–188, Jan., 1921.)—In the further search for filters which transmit ultra-violet rays [compare Miethe and Stenger, Abs. 981 (1920)] the author tested a number of yellow dyes of Schulz and Julius which show a certain transparency to some ultra-violet rays, though more opaque to blue and other rays. The dyes are tested in a quartz trough with a quartz spectrograph in such a way that the same slit, 6 mm. high, is used for exposures of 1, 2, 5, 15 seconds. In the diagrams the values of $k = 2\pi nx/\lambda$ (where nx is the absorption index) are plotted against λ; according to Beer the k values are proportional to the concentration. Flavazin L gave the best result, being fairly transparent between 320 and 290 $\mu\mu$. H. B.

1058. *Studies on Photographic Sensitisers.* II. **W. H. Mills** and **W. J. Pope.** (Phot. J. 60. pp. 253–266; Disc., 266–267, Nov., 1920.) —This paper deals with the carbocyanines, of which the most generally used sensitiser bears the trade names of Pinacyanol and Sensitol Red. [See Abs. 1067 (1920).] L. H. W.

1059. *Blackening of a Photographic Plate as a Function of Intensity of Light and Time of Exposure.* **P. S. Helmick.** (Phys. Rev. 17. pp. 135–146, Feb., 1921.)—*Three emulsions*, a slow one (Seed 23), a rapid one (Seed 27X), and a very rapid one (Seed Graflex), were coated on plate glass and illuminated for various lengths of time with various intensities of monochromatic light of wave-length 450, 550, and 650 $\mu\mu$. The results are given in curves and are found to be well represented, for a given emulsion and wave-length, by the *empirical equation for blackening*, $D = (1/a) \log [b - (b - 1)e^{-ct}]$, where $\log c = A + B \log I + C(\log I)^2$, and a, b, A, B, and C are constants. A graphical method of determining these constants employing a monographic chart is described. Schwarzschild's exponent p is shown to be equal to $(B + C \log I)^{-1}$, and is found to vary from 0·7 to 1·95 according to the emulsion, wave-length, and intensity. In using the *photographic method of measuring the intensity of a source of light*, it is obviously important to determine the constants of the equation for the blackening of the emulsion for the proper wave-length. The method of doing this is explained in detail. AUTHOR.

1060. *Photometric Methods and Apparatus for the Study of Colloids.* **S. E. Sheppard** and **F. A. Elliott.** (Am. Chem. Soc., J. 43. pp. 531–539, March, 1921.)—The more specific optical methods which may be applied to the study of dispersed systems are conveniently grouped under the following heads: (1) *Turbidimetry*, illustrated by the sulphur photometer and water turbidimeters. In this method the thickness of solution necessary to produce a given reduction in the visual resolution of some standard pattern is taken as proportional to the quantity of suspended matter. (2) *Photometry* of transmitted light, as in the Martens photometer or the spectrophotometer. (3) *Nephelometry*, based on the photometric comparison of unknown and standard suspensions to determine the quantity of suspended matter. (4) *Tyndallimetry*, involving the photometric measurement of the intensity of the scattered light from a Tyndall cone. This method, which is really an application of (2), has been very successfully applied by Werner, Mecklenburg, Tolman, etc. Two types of photometer are now described, distinguished as vertical and horizontal types, for the study of colloids. The vertical plane type easily lends itself to modification for use as a nephelometer, colorimeter, microphotometer, dispersimeter, and turbidimeter. The horizontal type is strictly a transmission and scatter photometer, of chief utility in determining particle size, comparative turbidities, and coagulation velocities. What is believed to be a relatively new principle in the photometry and dispersimetry of colloids is discussed and illustrated. The paper includes 10 diagrams. H. H. Ho.

1061. *Observations and Measurements upon Optically Active Crystals* (*$NaClO_3$*). **E. Perucca.** (N. Cimento, 18. pp. 112–154, Sept., 1919.)—In this paper the following matters are dealt with: The experimental arrangement for polarimetric measurements is described in detail and illustrated diagrammatically. The results of measurements of rotatory power for pure sodium chlorate crystals in the visible spectrum are given, as are also the measurements of the rotatory power for artificially coloured crystals of sodium chlorate. The crystallography of sodium chlorate is considered at some length and illustrated by means of diagrams and reproductions of photographs. A. E. G.

1062. *Peculiarities of Polarisation and Energy Distribution by Speculum Gratings.* **L. R. Ingersoll.** (Phys. Rev. 17. pp. 493–501, April, 1921.)—*Intensity Minima in Spectra of Speculum Gratings.*—A series of intensity minima, resembling absorption lines, are to be found in the continuous spectrum of a speculum grating at such wave-lengths as are being tangentially diffracted in other orders. They are limited to the azimuth of polarisation with electric vector perpendicular to the rulings and appear best in such gratings as show strong spectra in several orders. While they appear in the visible spectrum for a deeply ruled grating, in general they may be observed only for longer wave-lengths—say between $0 \cdot 8\ \mu$ and $2\ \mu$. Although simple energy considerations furnish a fairly satisfactory explanation of the phenomena, it is highly desirable that the Rayleigh-Voigt grating theory be modified and extended to fit these and similar facts or else that a new theory be developed.

Practical Importance to the Spectroscopist.—It is highly desirable that work on the Zeeman-effect or other polarisation phenomena with speculum gratings be arranged—as may easily be done—so as to avoid this effect. The same may be said of infra-red absorption measurements. AUTHOR.

1063. *The Spectrum of Electrically Exploded Wires.* **J. A. Anderson.** (Mt. Wilson Observat. Contrib. No. 178. Astrophys. J. 51. pp. 37–48, Jan., 1920.)—*High-temperature absorption spectra*, such as those given by the sun and some stars, have not been reproduced fully in the laboratory. The absorption spectra obtained with the arc and the electric furnace have been limited to wave-lengths below $0{\cdot}56\,\mu$ for iron and have not included the high-temperature lines. The author has developed *a method of obtaining high-temperature absorption spectra*, which consists in electrically exploding a fine wire in a confined space. When the explosion occurs in air confined in a tube or slot, the flash gives a brilliant continuous spectrum crossed by the absorption lines of the elements composing the wire. The spectrograms reproduced show that for *iron* an absorption spectrum was obtained which extends to $0{\cdot}66\,\mu$ and includes all classes of lines except the pronounced enhanced lines. *Copper, nickel,* and *manganin* were also investigated. When the method has been more fully developed it may be possible to imitate stellar absorption spectra of the solar type.

New Laboratory Source of Light.—By discharging a large condenser, charged to 26,000 volts, through a fine wire 5 cm. long, about 30 cals. of energy were dissipated in about 10^{-5} sec. If all this energy had gone into the 2 mgm. of wire it would have raised its temperature to about 300,000°. Actually, the brilliant flash which resulted had an intrinsic intensity corresponding to a temperature of about 20,000°, or about one hundred times the intrinsic brilliancy of the sun. The character of the spectrum and also the pressure developed depend, of course, upon the energy per unit mass and also upon the initial pressure and volume of the surrounding gas. When the wire was exploded within a tube or slot under a bell jar exhausted to 2 cm. pressure, a line *emission spectrum* was obtained. As the air pressure was raised the continuous background increased in intensity and the spectrum became more and more an *absorption spectrum*. Because of the high temperature, the *continuous spectrum* extends far into the ultra-violet. This source should be useful in studying the *pressure shift* of lines, as pressures of 50 atmos. can readily be obtained. The spectrograms already secured show the effect clearly. The *appearance* of the flash is shown by direct photographs. Its size corresponds to a speed of propagation in open air of about $3{\cdot}3$ km. per sec. Some striking *mechanical effects of the explosion* are briefly described.

Meteorites Falling into the Sun.—In a *theoretical discussion* the author points out that meteorites falling into the sun would be given a relatively enormous amount of energy in a short time and hence would be exploded by mechanical means much as his wires were exploded by electrical means.

Fine Wires.—*A simple method of producing on a lathe* wires weighing down to $0{\cdot}1$ mgm. per cm. has been developed. AUTHOR.

1064. *Characteristics of Absorption Spectra Produced by the Electric Furnace.* **A. S. King.** (Mt. Wilson Observat. Contrib. No. 174. Astrophys. J. 51. pp. 13–22, Jan., 1920.)—*Absorption Spectra of Metallic Vapours, Produced by the Electric Furnace.*—By placing a short plug of graphite in the middle of a tube furnace, a continuous spectrum corresponding to the temperature of the plug was obtained as a background for a pure absorption spectrum due to the hot metallic vapour. *Barium, calcium, cobalt, iron, nickel,* and *titanium* were investigated.

Relation of Absorptive Power to Temperature Class.—The furnace demonstrates, more clearly than is possible with the arc, the fact that lines of the same intensity in the emission spectrum may differ greatly in absorptive power. This variation was found to be closely related to the behaviour of the lines at different furnace temperatures. The lines relatively strong at low temperature are strongest in the absorption spectrum, these lines often being faint in the arc. As the temperature of the plug rises, lines appear in absorption which are given faintly in emission at lower temperature. The result is that the relative intensities in absorption correspond with those in the emission spectrum several hundred degrees lower.

Mixed Absorption and Emission Spectra of Metallic Vapours.—By placing the graphite plug beyond the middle of the furnace tube, mixed spectra were obtained; for whether the heated vapour emits or absorbs more light of a given wave-length depends on the relative temperatures of the plug and the vapour. Thus the lines of either the low temperature or the higher temperature could be obtained in emission or in absorption or suppressed at will. Striking effects were obtained with *calcium* and *iron*. By adjusting the background, the author secured on the same spectrogram the high-temperature lines in emission, the low-temperature lines in absorption, and intermediate lines suppressed. These experiments may help to *explain stellar spectra containing both bright and dark lines.* Experiments are also described in which the incandescent vapour in the tube, without a plug, gave an absorption spectrum, consisting only of those lines which in the emission spectrum at lower temperature are self-reversed.

Kirchhoff's Law; Application to the Absorption Spectra of Metallic Vapours in the Electric Furnace.—This is briefly discussed. AUTHOR.

1065. *Intensity Differences between Band Spectra Emitted by the Electric Furnace and the Arc.* **A. S. King.** (Mt. Wilson Observat. Contrib. No. 194. Astrophys. J. 53. pp. 161–164, March, 1921.)—Large-scale photographs of the "*cyanogen*" *band at* λ3883, made in the third order of a 30-ft. spectrograph, showed the A_1 series of lines is enhanced over the A_2 series so as to become the dominant series; also a new faint doublet appeared. The two series, then, seem not to belong to the same temperature class, and may be expected to be differently affected by pressure, etc. The "*cyanogen*" *band at* λ4216 also showed similar changes. In the *Swan band* λ5165 the triplet series is enhanced in the furnace spectrum with reference to the adjacent doublet series. AUTHOR.

1066. *Electric Furnace Spectrum of Manganese; Variation with Temperature to* 2400°. **A. S. King.** (Mt. Wilson Observat. Contrib. No. 198. Astrophys. J. 53. pp. 133–143, March, 1921.)—The spectrum produced in the tube-resistance furnace at 1700°, 2000°, and 2400° C. was examined from λ2795 to λ8200; but no lines were found beyond λ6500. Tables are given of the relative intensities of the lines in the arc spectrum and in the furnace spectra for the three temperatures; also the *temperature classification* of these lines according to the method used in previous articles. Some lines observed at 1560° C. include the triplet λ4031 to λ4035, still strong and well reversed at this low temperature. As with other furnace spectra, the ultra-violet wave-length limit is shorter the higher the temperature. In the discussion the interesting behaviour of some of the lines is pointed out. None of the enhanced lines given by Lockyer occur in the furnace spectrum. [See Abs. 1074 (1920).]
AUTHOR.

1067. *Spark Spectra of Iron and Cobalt in the Extreme Ultra-Violet.* **L.** and **E. Bloch.** (Comptes Rendus, 172. pp. 851–854, April 4, 1921.)—Measurements of the spark spectrum of nickel in the Schumann region have previously been given [Abs. 559 (1920)]. The present paper gives wave-lengths and intensities of 115 iron lines from $\lambda 1845$ to $\lambda 1530$, and of 143 cobalt lines from $\lambda 1846$ to $\lambda 1455$. A. W.

1068. *Spark Spectra (Cadmium and Lead) in the Extreme Ultra-Violet.* **L.** and **E. Bloch.** (Comptes Rendus, 172. pp. 803–805, March 29, 1921.)—Wave-length tables are given for 67 zinc lines in the region $\lambda 1840$ to $\lambda 1443$, 99 cadmium lines from $\lambda 1845$ to $\lambda 1415$, and 10 lines in the spectrum of lead between $\lambda 1822$ and $\lambda 1406$. Most of the lines are rather weak (intensity 4 or less), but the lead lines $\lambda 1821{\cdot}7$ and $\lambda 1796{\cdot}3$ are both of intensity 10. A. W.

1069. *Vacuum Spark Spectra in the Extreme Ultra-Violet of Carbon, Iron, and Nickel.* **R. A. Millikan, I. S. Bowen,** and **R. A. Sawyer.** (Astrophys. J. 53. pp. 150–160, March, 1921.)—*Spectroscopy of the Extreme Ultra-Violet.*—(1) *A concave grating* to be suitable for work in this region must satisfy far more rigorous demands than for work in the visible and should throw most of the light into the first-order spectrum. The authors therefore had some gratings ruled with great precision and with a light touch so that about half the original surface was left between the rulings. It was not found practical to increase the number of lines to more than 1100 per mm. (2) *Measurement of the wave-lengths.* Equations for the corrections to be applied to plate measurements because of the flatness of the plate and its inclination to the axis of the grating are derived, and the use of spectrum lines of higher order to determine this angle of inclination is explained.

Vacuum-spark Spectra of Carbon, Iron, and Nickel in the Extreme Ultra-Violet.—The intensities and wave-lengths, accurate to about 0·2 Å., of about 75 lines due to carbon ($\lambda 360$–$\lambda 1931$), of about 200 lines due to iron ($\lambda 271$–$\lambda 2153$), and of about 75 lines due to nickel ($\lambda 731$–$\lambda 1860$) are given in tables. AUTHORS.

1070. *Pressure-Shifts in Calcium Arc Spectrum, $\lambda 3150$ to $\lambda 6500$.* **L. F. Miller.** (Astrophys. J. 53. pp. 224–230, April, 1921.)—A 4-mm., 4-amp. arc between Ca electrodes, one water-cooled, the other pointed, was operated in a chamber in which the pressure was varied from 5 to 76 cm. of Hg. By using the second order of a 21·5-ft. grating, shifts of 0·001 Å. could be detected. Table II gives the mean results for 75 lines. The H and K lines, the P and T series lines, and a few other lines show a shift of 0·001 Å. or less. All lines which broaden toward the violet show a shift toward the violet; all others tend to shift toward the red. The shift is the same for all lines of each term of a series, and increases with the term number, except that there is an indication that for the lower term of the T_1 series the shift is positive instead of negative as in the case of terms 4 to 6. Mechanical shifts were eliminated by comparison with iron lines of class *a* and *b*. AUTHOR.

1071. *The Balmer Series of Hydrogen, and the Quantum Theory of Line Spectra.* **R. T. Birge.** (Phys. Rev. 17. pp. 589–607, May, 1921.)—*Balmer Series of Hydrogen.*—(1) *A rigid comparison of experimental with theoretical results* is the main purpose of the paper. It is concluded that Merton's measurements of the separation, half-width and relative intensity of the H_α and H_β doublets agree with values derived from the recent Bohr-Kramers developments of the quantum theory, if a general field of 100 volts per cm. is assumed. After the fine structure has been analysed and the "circle" line computed, determining the position of the components from the Sommerfeld theory and the relative intensities from the Bohr-Kramers theory, the frequencies of all lines are fitted into the Bohr relativity formula. (2) *The Rydberg constant* for H is then calculated to be 109,677·7 ± 0·2. (3) *A discussion of observations in mixtures of hydrogen and helium* made by Merton and Nicholson at relatively high pressures concludes the paper.

The Rydberg spectral series constant for a nucleus of infinite mass is computed to be 109,736·9 ± 0·2. AUTHOR.

1072. *Origin of Band Spectra.* **Y. Takahashi.** (Phys. Math. Soc. Japan, Proc. 3. pp. 20–28, Feb., 1921.)—Assuming a diatomic molecule consisting of two atoms at a distance *l* apart, the molecule rotating about an axis perpendicular to *l* through the centre of mass, and accepting the quantum relations of Bohr and Sommerfeld, it is shown that a formula representing a system of band spectra may be deduced from the oscillation of the atoms in the direction of *l*. The theory developed leads to good agreement with values deduced from viscosity, thermal conductivity, etc., for the diameter of the molecules of nitrogen and oxygen, and also gives fairly good results for the heads of the bands.

Applicability of the Author's Formula to Fulcher's Band (*ibid.*, pp. 30–33, March, 1921.)—Fulcher [Abs. 417 (1913)] isolated two triplet bands when investigating the low-potential discharge in hydrogen. Takahashi here shows that the above-mentioned formula will represent the Fulcher band if a positively charged hydrogen molecule is assumed in which two hydrogen atoms revolve about an electron. A. W.

1073. *Ultra-Violet Absorption Spectrum of Benzene Vapour.* **K. Schulz.** (Zeits. wiss. Phot. 20. pp. 1–35, Nov., 1920.)—After discussing previous work on this subject, the author describes his own measurements, which have been made with the help of a concave grating having a radius of curvature equal to 6·47 m. and ruled with 15,450 lines per inch. As source of light use was made of the iron arc, photographs being taken of the first-order spectrum; the positions of 75 bands were determined to within 0·01–0·1 Å.U., the results being compared with those obtained by Witte (1915). Between the members of a long series the mean difference in wave-length is found to be 92·1. T. H. P.

1074. *Magnetic Separation of Neon Lines and Runge's Rule.* **H. Nagaoka.** (Phys. Soc., Proc. 33. pp. 83–98; Disc., 98–99, Feb., 1921.)—Contains the results of an investigation of the Zeeman-effect for neon lines. The departures from Runge's rule—that the magnetic separation of the lines are aliquot parts of the separation of the normal triplet—are discussed. It is concluded that such discrepancies are due to variations of the ratio *e*/*m*. AUTHOR.

1075. *Corpuscular Spectra of the Elements.* **M. de Broglie.** (Comptes Rendus, 172. pp. 274–275, Jan. 31, 1921.)—The photoelectric electrons emitted by bodies excited by Röntgen rays are characterised by their velocity, which can be measured by their deviation in a magnetic field. In this way a spectrum of velocities can be obtained for the corpuscles expelled. Rawlinson and Robinson [Abs. 182 (1915)] obtained in this way lines more or less sharp with radiators of iron and lead, and Kang Fu Hu [Abs. 1164 (1918)] showed that for silver and tin two lines were obtained which were connected with the K-series of the metals by quantum relations. The author has carried out experiments on the elements from molybdenum to barium, and has found corpuscular rays for these elements corresponding to the K-rays. At a point of the spectrum corresponding to the K-absorption band of the elements, there is found a selective emission band of photoelectric corpuscles, with an edge sharp on the side of smaller energy; and the electrons at the beginning of the band have the velocity corresponding (by the quantum relation) to the discontinuity of absorption of the X-rays. There appear to be other bands as well, but this statement can only be given with reserve. A. W.

1076. *Corpuscular Spectra of the Elements.* **M. de Broglie.** (Comptes Rendus, 172. pp. 527–529, Feb. 28, 1921.)—In a former paper [see preceding Abstract] the author has shown that the principal characteristics of the X-ray spectra of the elements can be simply explained from a consideration of the magnetic velocity spectra of the electrons emitted by these elements, when they are exposed to the radiation of a beam of X-rays from an ordinary tube. The author now gives further details and results relating to this investigation. It is indicated how such a study of corpuscular spectra might throw light on the mechanism of ejection corpuscles. A. B. W.

1077. *Bohr's Model Atom and Corpuscular Spectra.* **M.** and **L. de Broglie.** (Comptes Rendus, 172. pp. 746–748, March 21, 1921.)—Bohr's atom comprises a central positive charge, around which gravitate electrons in certain stable trajectories, which have been called the K, L, M, etc., rings, going from the centre outwards. To extract an electron from one of these rings energy of amount W_K, W_L, etc., must be supplied, and if this work results in a periodic radiation, the quantum theory demands that the product $h\nu$, where ν is the frequency of this radiation, should be at least equal to W_K, W_L, etc.

Assuming that the transference of energy to the radiation is made by quanta $h\nu$, and that we ought, in order to obtain the velocity of the electron leaving the atom, to subtract the work of extraction corresponding to the ring concerned, it follows that a radiation of frequency ν, high enough for its quantum to be greater than the work of extraction from the K, L, etc., rings of a radiator, would give electrons K, L, etc., having energies $h(\nu - \nu_K)$, $h(\nu - \nu_L)$, etc., on leaving the atom. If the corpuscular spectrum of the velocities of the emitted electrons is obtained, there should be found a line corresponding to each of these energies. In the case where a radiator is excited by a continuous spectrum of rays having a superior limit of frequency ν, the preceding lines would become bands with sharp edges on the side of greater corpuscular velocities.

The radiator also emits X-fluorescence rays K, L, M, etc., and these rays correspond to the expulsion of electrons L, M, N, etc., possessing the quantum of the fluorescence rays diminished by the energy W_L, W_M, W_N, etc., required for leaving the atom.

If the radiator is surrounded by a thin layer of another body whose Bohr rings are K′, L′, M′, etc., the radiators of fluorescence of the first excite the corpuscular radiations of the second, and there would thus be (for the ray α, for example) electrons having energies $h\nu_{\alpha K} - W_{K'}$, $h\nu_{\alpha} - W_{L'}$, etc. These terms will be greater or less than those corresponding to the first radiator alone according to the mutual position of the two radiators in the Mendéléef series. The corpuscular rays thus observed will appear therefore advanced or retarded with respect to their position when the first radiator alone is excited. Experiments carried out [Abs. 1075 (1921)] appear to confirm the above conclusions.

A. W.

1078. *Laws of Photoelectric Emission for High Frequencies.* **M. de Broglie.** (Comptes Rendus, 172. pp. 806–807, March 29, 1921.)—Consideration of the experimental results previously obtained for numerous elements [see Abs. 1075 (1921) and preceding Abs.] leads to the following conclusions. If a beam X of frequency ν is used to illuminate a radiator A, for which the Bohr rings correspond to values W_K, W_L, W_M, etc., for the work of extracting the electrons, a series of corpuscular rays is obtained having for quanta $h\nu - W_K$, $h\nu - W_L$, $h\nu - W_M$, etc., if the frequency ν is higher than the frequency K; *e.g.*, a radiator of copper illuminated by a tube with a rhodium antikathode, giving an intense radiation of the rays of this metal, presents a magnetic corpuscular spectrum of velocities comprising 4 rays, which correspond to: $\nu_{\alpha K}$ (rhodium) $- W_K$ (copper), $\nu_{\alpha K}$ (rhodium) $- W_L$ (copper), $\nu_{\beta K}$ (rhodium) $- W_K$ (copper), $\nu_{\beta K}$ (rhodium) $- W_L$ (copper). The value of W_L is taken equal to the quantum for the ray β_5 of the L-spectrum in the elements for which this discontinuity has not been measured directly.

The radiator A gives also fluorescence rays which furnish corpuscular rays following the same law as the above; but in this case, instead of 4 rays, only three distinct rays are observed, because the difference in frequency of the α- and β-rays of the K series is exactly equal to $W_L - W_M$. The corpuscular rays corresponding to rays of X-radiation in the incident beam have the appearance of bands with a sharp edge on the side of greater energy when their frequency is high (Pt, W); they have the appearance of rays, wide and diffuse on one side, when they are less penetrating (Rh).

These considerations appear to explain both qualitatively and quantitatively, within the limits of the experiments, all the observed effects except one: that which consists in the presence of a corpuscular emission band with an edge fairly sharp on the side of smaller energy, and beginning near the quantum of the K-absorption band of the X-rays.

A. W.

1079. *Phosphorescence; Action of Red and Infra-Red Rays.* **M. Curie.** (Comptes Rendus, 172. pp. 272–274, Jan. 31, 1921.)—Describes experiments on the action of red and infra-red rays on various phosphorescent substances. Two sources of light were employed; the first consisted of a mercury arc provided with a glass screen containing nickel oxide. This glass has two transmission bands, one in the red where the mercury arc emits no rays, and the centre of the other coincides with the mercury line λ3660, which is transmitted with no appreciable diminution of intensity. The second source was an arc lamp provided with a screen transmitting radiations at the beginning of the infra-red and a small amount of visible red light. As previously known, the long-wave radiations suppress the phosphorescence of certain substances, and this was shown in the case of phosphorescent zinc sulphide by concentrating the infra-red rays on a luminous patch produced by the λ3660 radiation. A black spot could be seen where the infra-red rays were concentrated, surrounded by a luminous patch. If the sulphide plate was then moved, the black spot became luminous, and there was also seen a dark streak where the infra-red rays had passed. The reinforcement of the dark spot varied in intensity and in duration with the phosphorescent substance used.

With a fluorescent substance no black spot or variation of intensity could be observed at the place where the infra-red rays were concentrated. A. W.

1080. *Law of Excitation of the Characteristic Primary X-rays.* **R. Brunetti.** (N. Cimento, 18. pp. 266–284, Nov., 1919.)—A series of experiments are described which are intended to illustrate the law of the excitation of primary X-rays, $h\nu = \frac{1}{2}mv^2$. These experiments have been carried out with the following elements: Al, Fe, Cu, Zn, Sn, Cd, Pt, Pb. A. E. G.

1081. *Polarisation-Condition of the X-radiation in the "Brennfleck."* **K. W. Hausser** and **R. Thaller.** (Deutsch. Phys. Gesell., Verh. 21. pp. 603–605, Sept. 30, 1919.)—Describes a study of the X-radiation in the neighbourhood of the region of the "hot" spot on the antikathode, using the Lilienfeld pinhole camera method. Photographs of various "Brennflecks" are shown in illustration. The results support Lilienfeld's theory. A. B. W.

1082. *Post-kathodic X-Rays.* **R. Brunetti.** (N. Cimento, 19. pp. 88–98, Feb., 1920.)—It is concluded as the result of the work here described that a new region of high-frequency radiation has been put in evidence. A. E. G.

1083. *Mass Absorption and Mass Scattering Coefficients for X-Rays of Wave-length* 0·13–1·05 *Å.U.* **C. W. Hewlett.** (Phys. Rev. 17. pp. 284–301, March, 1921.)—I. *Present Status of the Problem.*—The mass scattering and mass absorption coefficients are defined, and a brief summary is given of the results of previous absorption and scattering measurements in the regions of wave-lengths on the short-wave side of the K radiation of the absorbing substance.

II. *Absorption and Scattering of Homogeneous X-Rays by Water, Lithium, Carbon, Nitrogen, Oxygen, Aluminium, and Iron at various Wave-lengths within the Region Bounded by* 0·13 *and* 1·05 *Å.U.*—(1) The total absorption coefficient of homogeneous X-rays obtained by passing the X-rays from a Coolidge tube through a Bragg X-ray spectrometer was measured for the above-named materials at various wave-lengths in the range indicated. The total mass absorption coefficient was found to be proportional to the cube of the wave-length of the X-rays over certain regions, but for all the substances where the investigation was complete over the whole range mentioned, the constant of proportionality was different for different ranges of wave-length. (2) *Hydrogen* is apparently an exception to the above statement, for its total mass absorption coefficient appears to be proportional to the 9/2 power of the wave-length of the X-rays. (3) *The constant which multiplies the cube of the wave-length* to give the true mass absorption coefficient is found to be approximately proportional to the cube of the atomic number of the absorbing element, except for Li, and this indicates that Moseley's law will not be found to hold for this latter element. (4) *The true mass absorption coefficient for iron* is apparently not proportional to the cube of the wave-length for waves between 0·70 and 1·05 Å.U. No explanation is suggested for this. (5) *The true mass absorption coefficient* for the elements, with the exception of iron, for wave-lengths less than 0·20 Å.U. are smaller than is to be expected from theory if the electron has a diam. of the order of 10^{-13} cm. Compton's modification of the expressions for these absorption coefficients accounts for these experimental results if we assign to the electron a diam. of $0\cdot75$ to $0\cdot85 \times 10^{-10}$ cm. (6) *The lack of this decrease in the coefficients for iron* is attributed to a shrinkage in the diam. of the electrons in the atoms on account of the closer packing of the electrons in this element. (7) *The mass scattering coefficient* of all the substances used is less than that given by Thomson's theory, but no explanation has been found. (8) *The mass scattering coefficient for hydrogen* is approximately twice that for the other elements, and this is interpreted as further evidence that hydrogen has twice the number of scattering electrons per unit mass as the other elements. (9) *The mass scattering coefficient for iron* apparently increases for wave-lengths longer than 0·70 Å.U. It is suggested as an explanation of this fact that the distance between the scattering electrons in the iron atom is of the order of magnitude of 0·70 Å.U.

III. *Projects for Further Absorption and Scattering Measurements.*—(1) The scattering of X-rays should be measured as a function of the angle of scattering. (2) The absorption and scattering of hydrogen should be measured directly. AUTHOR.

1084. *X-Ray Spectrographic Observations with Cellulose.* I and II. **R. O. Herzog, W. Jancke,** and **M. Polanyi.** (Zeits. f. Physik, 3. 3. pp. 196–198, and 3. 5. pp. 343–348, 1920.)—The papers deal with an X-ray analysis of the "crystalline" structure of cellulose—employing the method of Debye and Scherrer. Cotton, ramie fibre, wood-fibre, art-silk, and a fibre of "Viskose" were examined, the results obtained being almost identical in all cases. Observations lead to the result that a rhombic crystalline structure exists in cellulose, the ratio of perpendicular axes of the elementary parallelopiped being 0·6935 : 1 : 0·4467. A. B. W.

1085. *Scattering of X-Rays in Water.* **F. Dessauer** and **F. Vierheller.** (Zeits. f. Physik, 4. 1. pp. 131–145, 1921.)—Measurements have been made of the distribution of intensity in cones of radiation of four different volumes in the ratio 1/100 to 1/10 to 1/1 in water; the experiments being carried out with three different hardnesses of radiation. The lines of equal intensity have been determined under the varying conditions of experiment.

The intensity of the scattered radiation in water increases (1) with increasing exciting voltage, (2) with the volume under radiation, approaching a limit, (3) with increasing depth, approaching a limit, (4) with approach towards the central beam.

The upper limit of the absorption coefficient in water for three different voltages has been determined by a new method. The lower limit of the scattering coefficient σ_{water} has a value 0·074 which is probably constant for the range of voltage under consideration. A. B. W.

1086. *Reflection of X-Rays from Calcite.* **B. Davis** and **W. M. Stempel.** (Phys. Rev. 17. pp. 608–623, May, 1921.)—*Percentage of monochromatic X-rays reflected from calcite, for wave-lengths ranging from* 0·3 Å. *to* 0·8 Å. was studied by means of a *double X-ray spectrometer.* A narrow beam of general radiation fell at an angle upon a crystal designated as A and the reflected beam was allowed to fall upon a second crystal designated B. The intensity of the beam from B was then compared, by means of the ionisation produced in an ionisation chamber, with the direct beam from A. *Percentage reflection was found surprisingly large* when the surfaces of the two crystals were strictly parallel. The percentage reflection will depend upon the character of the beam reflected and therefore upon crystal A.

Significant energy distribution curves were found when the crystal B was rocked through a small angle on either side of parallelism. *A very sensitive micrometer motion* was provided for rotating crystal B about both a horizontal and also about a vertical axis, necessitated by the extremely narrow energy distribution curves obtained. *Three pairs of crystals* were investigated. Pair ($A_1 - B_1$) where A was a rather imperfect specimen of Montana calcite and B_1 was a clear specimen of Iceland spar. The surface of both crystals was polished. Pair ($A_2 - B_2$). Here a clear specimen of Iceland spar was split. The two split surfaces were polished and the crystals mounted so that reflection was from the surfaces that had been contiguous before splitting. Pair ($A_3 - B_3$) was another pair obtained by splitting a clear specimen of Iceland spar, but leaving surfaces unpolished; mounting the same as ($A_2 - B_2$).

The rocking curves vary greatly in width, depending upon the nature of the reflecting surface; 16″ of arc for width of half maximum when crystal is a good sample and the surface is the natural split surface (not polished). When crystals are not perfect samples and surface polished as much as 57″ of arc was obtained. For any one pair of crystals the width of the half maximum of these rocking curves is a *linear function of the wave-length* with a *definite finite intercept* depending upon the condition of the surface. The more perfect the crystal the less does this width depend upon wave-length.

Percentage reflection is a function of wave-length, but is less so the more perfect the crystal. For the pair ($A_3 - B_3$), it was nearly independent of wave-length. It would seem that the *reflection from a really perfect crystal would be independent of wave-length and would probably be greater than* 50 %. AUTHORS.

1087. *Intensity of Reflection of X-Rays by Rock-Salt.* **W. L. Bragg, R. W. James,** and **C. H. Bosanquet.** (Phil. Mag. 41. pp. 309–337, March, 1921.)—The absolute values of the reflecting power for different faces of rock-salt have been measured for eighteen glancing angles over a range between 5° 30′ and 30° 0′. The values obtained have been compared with those calculated from the theoretical formulæ for reflection deduced by Darwin [Abs. 1079 and 1262 (1914)] and Compton [Abs. 308 (1917)] and it is shown that they afford strong confirmation of the accuracy of these formulæ. The greatest care was taken to make the measurements as accurate as possible, in order that they might serve as a basis for an analysis of the arrangement of the electrons in the atom. Possible arrangements are discussed. In order to confirm the results, the effect of temperature on the intensity of reflection must be more fully determined. The authors intend to make a series of determinations at liquid-air temperature, in order to be able to extrapolate to the values at absolute zero. It is hoped to extend the measurements over a wider range of angles at low temperatures. It is intended, further, to repeat the experiments with KCl in order to check the formula in this case. Sylvine affords a simpler case for investigation than rock-salt, since the ions of potassium and chlorine will, in all probability, have a very similar structure. A. B. W.

1088. *Doublets in the K-Series of X-Ray Spectra.* **N. Stensson.** (Zeits. f. Physik, 3. 1. pp. 60–62, 1920.)—An analysis of Siegbahn's observations [see Abs. 1397 (1919)] on the K-series of X-ray spectra, particular attention being paid to the α-doublets in the region copper–chlorine. A comparison is made between the experimental observations of Siegbahn and the theoretical deductions of Sommerfeld relating to the frequency difference between $K\alpha_1$, $K\alpha_2$, $K\alpha_3$, and $K\alpha_4$ doublets. The experimental results appear to agree well with the theory. A. B. W.

1089. *Production of High-frequency Radiation in Closed Gas-Vessels.* **A. Becker** and **H. Holthusen.** (Ann. d. Physik, 64. 7. pp. 625–645, April 19, 1921.)—A theoretical paper dealing with the secondary X-radiation from the contained gas and from the walls of a closed vessel. Does not permit of a concise abstract. A. B. W.

1090. *Absorption Limits in the L-Series.* **G. Hertz.** (Zeits. f. Physik, 3. 1. pp. 19–25, 1920.)—Experiments are described and results are tabulated indicating the critical absorption wave-lengths of the L-series for the following elements: Cs, Ba, La, Ce, Pr, Nd. The observations are applied to test Kossel's relation $\nu_{K_\alpha} = \nu_{K_A} - \nu_{L_{A_1}}$, and are found to be in good agreement when Siegbahn's values for ν_{K_α} are employed. Excellent agreement is also obtained when the observed frequency-difference between the absorption limits $(A_2 - A_1)$ are compared with Sommerfeld's theoretical frequency-difference $(\beta - \alpha')$ of the L-doublets. A. B. W.

1091. *Critical Absorption Frequencies of the L-Series.* **A. Smekal.** (Zeits. f. Physik, 3. 4. pp. 243–246, 1920.)—Measurements of the critical absorption frequencies of the L-series made by G. Hertz [see preceding Abstract] confirm the statement of the author that only three critical frequencies exist and that the A-doublet is not real. A. B. W.

1092. *Röntgenograms Obtained by Means of Mica Piles Composed of Crossed Lamellæ.* **F. M. Jaeger.** (K. Akad. Amsterdam, Proc. 23. 5. pp. 676–678, 1921.)—It was stated previously [Abs. 89 (1921)] that the röntgenogram obtained by means of a system of mica lamellæ crossing at definite angles ϕ is not a mere superposition of the images obtained by means of each lamella separately. The results of further investigations show that this conclusion cannot be considered as justified in its generality and that the images obtained must really be considered to be, at least in their principal features, superpositions of the images of a single lamella turned with respect to each other through the angle ϕ. Certain deviations do, however, occur: some spots were lacking in the last photographs which were visible in the film-image with moderate intensity, and generally the relative intensities of the spots were different from those in the image of the combined films. These deviations are explainable partly by the influence of a selective absorption of some wave-lengths and, to a greater extent, by a marked veiling of the background of the photographic plate. T. H. P.

1093. *X-Ray Crystal Analysis of Thirteen Common Metals.* **A. W. Hull.** (Phys. Rev. 17. pp. 571–588, May, 1921.)—The author's method of powder analysis was used. In the case of anisometric substances, the crystal system and axial ratio were found by means of plots by the method described in the preceding paper. The lattices of ***chromium, molybdenum,*** and ***tantalum*** were found to be body-centred cubes with sides **2·895, 3·143,** and **3·272 Å.** respectively; ***cobalt α, nickel, rhodium, palladium, iridium,*** and ***platinum*** have face-centred cubic lattices with the sides of the cubes **3·554, 3·540, 3·820, 3·950, 3·805,** and **3·930 Å.** respectively; ***cobalt β, zinc, cadmium,*** and ***ruthenium*** have hexagonal lattices of the "close-packed" type with axial ratios 1·63, 1·86, 1·9, and 1·59 respectively and with the triangular sides **2·514, 2·670, 2·960,** and **2·686 Å.** respectively; and ***indium*** has a face-centred tetragonal lattice with axial ratio 1·06 and the side of elementary prism 4·58 Å. The structures found for cadmium, zinc, and indium are close-packed arrangements of solid prolate spheroids, while that for ruthenium is a close-packed arrangement of oblate spheroids. AUTHOR.

1094. *Graphical Determination of Hexagonal and Tetragonal Crystal Structures from X-Ray Data.* **A. W. Hull** and **W. P. Davey.** (Phys. Rev. 17. pp. 549–570, May, 1921.)—*Graphic Method for Interpreting X-Ray Patterns of Powders.*—For each type of lattice the logarithms of the theoretical spacings of the different planes are plotted as functions of the axial ratio. Six such plots are reproduced, three for the hexagonal and three for the tetragonal system. By plotting the logarithms of the observed spacings on the edge of a strip of paper, this may be fitted by trial to the theoretical plot; the axial ratio and type of lattice being thus found in a few minutes.

Crystal Structure of Zn, Cd, In.—As examples three complete analyses are given. *Zinc* is shown to be a hexagonal close-packed assemblage of prolate spheroids. The axial ratio is 1·860 and the side of the unit triangle 2·760 Å. *Cadmium* shows a structure like that of Zn, with axial ratio 1·89 and elementary triangle 2·980 Å. *Indium* shows a structure nearly like Al (cubic close-packed), viz., a tetragonal close-packed arrangement of prolate spheroids, with axial ratio 1·06 and a unit square of 4·58 Å. AUTHORS.

RADIO-ACTIVITY.

1095. *Collision of α-Particles with Hydrogen Atoms; Atoms Liberated in Excess of Theoretical Number.* **E. Rutherford.** (Phil. Mag. 41. pp. 307–308, Feb., 1921.)—Reference is made to two newly developed methods of counting "H-atoms" produced by close collision of α-particles. The general results so far obtained by these methods indicate that the number of H-atoms liberated is much larger than the theoretical number to be expected from point nuclei and possibly even greater than the author's original estimate [see Abs. 912 (1919)]. The results also confirm the observation that the H-atoms tend, for the high velocities of the α-particle, to be shot forward in the direction of the α-particle, but not to the same extent as the preliminary experiments showed. The author draws attention to a slip in the original paper (*loc. cit.*), which, however, is of little importance to the main argument. A. B. W.

1096. *Chemical Effects of α-Radiations.* **E. Wourtzel.** (J. de Physique et le Radium, 2. pp. 53–61, Feb., 1921.)—Mathematical discussion of the experiments on the chemical reactions caused by α-rays when radium emanation is confined in glass vessels together with various gases (NH_3, H_2S, N_2O, CO_2) [Abs. 632 (1920) and 263 (1921]. The formulæ agree with Lind [Abs. 759 (1919)] whose formula covers a wider range of gas pressure and volume (diameter of bulb) than Lind supposed. The author differs from Lind, however, as to some numerical data and some conclusions. The formula of Duane and Laborde cannot be applied to the experimental conditions of Scherrer and of the author. The synthesis by α-radiations of water from electrolytic gas (Lind) differs from the decomposition of NH_3 because in the latter case only the energy absorbed by the NH_3 molecules is transformed into chemical energy, whilst the energy absorbed by N_2 and H_2 is lost. Both pure H and O can be activated by the radiations to react with other activated (and possibly with non-activated) molecules; but the reactions appear too complex so far for discussion. Reactions need not be purely ionic, and the author agrees with Debierne—he was said by Lind to differ—stating more precisely even that chemical reactions are due to the shock between α-particles and molecules rather than to collisions between molecules and molecules. H. B.

1097. *Collisions of α-Particles with Hydrogen Nuclei.* **C. G. Darwin.** (Phil. Mag. 41. pp. 486–510, March, 1921.)—In a series of papers Rutherford [see Abs. 912 (1919)] treated of a long course of experiments on this subject. The first of these papers dealt with hydrogen, and he drew several interesting conclusions, the most striking of which was that in these collisions the α-particle and the hydrogen nuclei could not both be regarded as simple point-charges. The object of the present paper was to submit these experiments to a more rigorous analysis, and as to try and discover more definite information about the structure of the nucleus. The author deduces from the experimental data what he calls the "collision relation," and shows that this relation is quite different from that for the collision of two point charges. The remainder of the paper describes an attempt to make models of nuclei which shall give the same "collision relation" as the experimental. The models all obey the inverse square law at great distances, and the investigation is limited necessarily to cases where the orbits are integrable, which makes them rather artificial. In all the models considered, one particle is still taken as a point charge, and the complexity is attributed to the other. In view of the trend of modern physics, it is assumed that the α-particle has the complex nucleus. From the first model the author concludes, with some probability, that experimental data cannot be accounted for, if the α-particle is equally likely to be orientated in any direction—in fact, Rutherford's suggestion of a "plate" nucleus (radius 3×10^{-13} cm.) is supported. Two plate-like models are tried and are seen to give closer resemblance to the experimental curves. For the present, however, until the latter are confirmed by experiments now in progress, the author reserves his conclusions.

A. B. W.

1098. *Distribution of Active Deposits of Radium, Thorium, and Actinium in Electric Fields.* **G. H. Briggs.** (Phil. Mag. 41. pp. 357–377, March, 1921.)—In his experiments on this subject the author has confirmed Wellisch's conclusion [see Abs. 568 (1915)] that a definite percentage of the active deposit atoms from RaEm is initially positively charged at the end of the recoil path, the remainder being neutral. The error of Henderson's experiments [Abs. 448 (1916)] is pointed out. The author indicates the importance of the part played by the recoil of RaB from the electrodes, and the percentages of RaB initially positively charged in various gases have been measured; from this the percentages of RaA positively charged have been calculated from experiments with RaEm.

An explanation of the difference in distribution on the anode and kathode of the active deposits of radium, thorium, and actinium has been given on the assumption that the percentages of ThA and AcA and of ThB and AcB, initially positive in the gas are identical with those of RaA and RaB respectively, as is to be expected from their isotopic nature. The distribution of the active deposit was experimentally determined for eight gases in a parallel-plate vessel, and found to be consistent with the theory, as also were Lucian's results [Abs. 189 (1915)], for the distribution of actinium active deposit in air in a cylindrical vessel.

An apparent connection between the percentage of recoil atoms initially positive in a gas and the temperature at which the gas begins appreciably to dissociate has been indicated and a theory, based on the assumption that the molecules of a gas are decomposed by the deposit atoms during their recoil, is given to explain the behaviour of the deposit atoms.

A. B. W.

1099. *Mobility of Radio-active Ions in the Bunsen Flame.* **H. Schönborn.** (Zeits. f. Physik, 4. 1. pp. 118–130, 1921.)—It is shown that the radio-active recoil atoms ThC$''$ in the ordinary luminous gas flame carry positive charges. The conditions have been examined under which it is possible to obtain a uniformly continuous emission of radio-active ions from a metallic electrode in the flame, without the occurrence of the disturbing factor of corrosion of the metal surface. Careful measurements have been made of the mobility of ThC$''$-atoms in a Bunsen flame, and the dependence of the mobility on the temperature of the flame. As a result of such observations it is shown that the mobility of the positive ions at the temperature of the Bunsen flame has a value lying between 200 and 400 cm./sec. per volt/cm. This result is in agreement with the observations of Lusby [Abs. 367 (1912)] and in contradiction to the results of Andrade (Dissertation, Heidelberg, 1911).

A. B. W.

HEAT.

1100. *Anomalous Dilatation of Gold-Copper Alloys.* **A. Portevin** and **J. Durand.** (Comptes Rendus, 172. pp. 325–327, Feb. 7, 1921.)—Gold containing about 20 % of copper is known to be brittle, but this can be cured by tempering [Abs. 1116 (1919)]. The effect is due to a transformation already studied by Kurnakov [Abs. 483 (1916)]. The authors test an alloy with 25·2 % of copper, previously tempered at 700°, in a Chevenard dilatometer. The heated alloy first contracts, then expands suddenly by several thousandths near 400°, contracts again when further heated to about 600°; a similar inverse curve is described on cooling, but the sudden change then takes place near 350°, the heating and cooling curves intersecting. When in a series of tests the heating is pushed only to 100°, 200°, or 300°, the heating and cooling curves do not intersect; when the heating is carried to 400° and to 500°, the peculiar intersecting curves are observed. The gold-copper alloy thus behaves somewhat like steel, but the anomaly is reversed. H. B.

1101. *Specific Heat and Thermal Dilatation of Regular Crystals.* **K. Försterling.** (Zeits. f. Physik, 3. 1. pp. 9–18, 1920.)—According to the theory of specific heat as developed by Einstein and Nernst and applied to crystals in Born's "Dynamik der Krystallgitter" [c.f. Abs. 446 (1913)], the energy content of a polyatomic crystal consists of two components: U_1, due to the elastic waves passing in all directions (Debije) and U_2, due to the atomic oscillations which the atom-lattices of the crystal, taken as rigid systems, describe with respect to one another. The U_2 might be determined if the atomic frequency ν were known, and U_1 can theoretically be defined, but the mathematical calculations offer great difficulties. The author deduces approximate formulæ for U_1 which he tests with respect to crystals of rock-salt, sylvine, fluorspar, and pyrite. Thermal dilatation and specific heat are intimately related, but the formulæ for crystals are very complex. Physically we may imagine that the elastic waves deform the crystal faces until the elastic forces balance the wave-pressure which is analogous to the radiation-pressure. There are very few data on thermal dilatation of crystals: Röntgen and Grüneisen [Abs. 1062 (1919)] for diamond, Valentiner and Wallot for fluorspar and pyrite [Abs. 1542 (1915)], and definite conclusions are not drawn. H. B.

1102. *Thermal Effect of Slow Current of Air past Series of Platinum Wires; Application to Hot-Wire Anemometers.* **J. S. G. Thomas.** (Phil. Mag. 41. pp. 240–258, Feb., 1921.)—Describes experiments on the effect of a slow stream of air passing over a series of 11 fine Pt wires placed transversely to the direction of flow. The temperature-changes in each wire at various speeds of flow are shown graphically, and the application of the results to the construction of sensitive directional hot-wire anemometers is discussed. J. W. T. W.

1103. *Properties of Steam.* **H. L. Callendar.** (Engineering, 111. pp. 63–65, Jan. 21, and pp. 93–97, Jan. 28, 1921; also Engineer, 131.

p. 353, April 1, 1921.)—Both articles, reviews of Callendar's treatise on "The Properties of Steam and Thermodynamic Theory of Turbines," 1920, give brief resumés of the author's investigations of the constitution of vapours generally and the properties of steam in particular. The equation of state of a perfect gas $PV = RT$, when modified into the form $P(V - b) = RT$ to allow for actual gases not being continua, but possessing a minimum volume, accounts for the slight heating of H expanded through a porous plug which was observed by Kelvin and Joule, but not for the slight cooling observed in the case of most other gases. This is explained by the absorption of energy involved in the molecular dissociation accompanying expansion, and led to the further modification of the equation of state into the form $V - b = RT/P - c$, where c is the "co-aggregation" volume, representing the diminution of volume due to partial association, and must be expressible as a function of any two of the variables, P, V, and T, and may be a function of one only. The form suggested by van der Waals in 1873, giving a very complicated expression for c, although leading to fruitful investigations, has defied all attempts to fit it to actual observation, and this in spite of its expressing merely a qualitative relation between the T, P, and V of a gas, and even as complicated by Clausius it entirely fails to represent the behaviour of CO_2. It has, in fact, come to be a hindrance rather than a help. Prior to Callendar's work, engineers had accepted for some three generations Regnault's conclusion that the total heat of steam was represented by a formula expressible in Fahrenheit units as $H = 1091 \cdot 7 + 0 \cdot 305(t - 32)$. Peabody's "throttling calorimeter," based on this formula, and devised for estimating the quality of steam supplied to engines under test, gave results which, according to Regnault's formula, made the wetness of the steam supplied by the boilers a negative quantity, *i.e.*, represented the steam as superheated, which was certainly not the case. The Germans had used empirical formulæ, and were followed uncritically by American computors of elaborate tables which, when tested by calculating the specific heat of steam by two equivalent thermodynamical methods, led to discrepancies amounting to as much as 20 %. Callendar attacked the problem by devising new and highly accurate methods of determining total and specific heats and also of determining with precision the law for the adiabatic expansion of steam. Then deducing the value of c from the cooling effect when a gas is expanded through a porous plug or restricted orifice, he showed that for most practical purposes it may be taken as a function of the temperatures only, and written $c = c_1 (T_1/T)^n$, where c_1 is the value of c at the temperature T_1. Hence he showed that $V - b = RT/P - c_1(T_1/T)^n$, known as the Callendar characteristic equation. By means of this and thermodynamic principles he showed in his great paper in the Roy. Soc. Phil. Trans., 1900 [Abs. 374 (1901)], that formulæ expressing all the properties of steam were deducible. G. W. de T.

1104. *Specific Heats of Vapours.* **A. Leduc.** (J. de Physique et le Radium, 2. pp. 24–30, Jan., 1921.)—The author has previously described a method of calculation for the principal specific heats C and c of vapours and for their ratio γ from the immediate neighbourhood of saturation to the superheated condition. The present paper is an extension of the former work. The classical formulæ of van der Waals and of Clausius, which have the advantage of generality, but fail in accuracy, are replaced by a formula which represents the facts much more accurately at all temperatures when the pressure does not exceed 1/20th (or even 1/10th) of the critical pressure, namely: $Mpv = RT\phi(T, p)$, where M is the molecular mass, R the universal constant which the author has determined experimentally to be 8319×10^4 c.g.s., and ϕ the relative molecular volume of the vapour with respect to a perfect gas, *i.e.*, the ratio of the experimental specific volume to that calculated from the expression $Mpv = RT$. Experiment shows that ϕ reduces to unity as p tends towards zero, and is accurately represented within the above pressure limits by an empirical formula, $\phi = 1 - mp - np^2$, derived from that of Regnault, where m and n are functions of T which are determined from previously established formulæ based on the principle of corresponding states. The following expressions are then deduced:

$$\partial v/\partial T = R/Mp\,.\,(\phi + T\,.\,\partial\phi/\partial T) = R/Mp\,.\,(1 + \epsilon),$$
$$\partial p/\partial T = p/T\,.\,(\phi + T\,.\,\partial\phi/\partial T)/(\phi - p\,.\,\partial\phi/\partial p) = p/T\,.\,(1 + \epsilon').$$

C is then calculated for superheated vapours under a pressure $p < F_{max}$, and found to be: $C = \frac{R}{JM}(1 + \epsilon_p)\,.\,\frac{T}{F}\frac{dF}{dT} + \frac{1 + \epsilon_p}{1 + \epsilon_m}\,.\,c''$, where c'' = the specific heat of the saturated vapour. For vapour in the immediate neighbourhood of saturation $C_s = \frac{R}{JM}(1 + \epsilon_p)\frac{T}{F}\frac{dF}{dT} + \frac{d\phi}{dT} - \frac{L}{T}$. The ratio γ is determined from $\frac{\gamma}{\gamma - 1} = \frac{1}{1 + \epsilon_p'}\left[\frac{T}{F}\frac{dF}{dT} + \frac{1}{1 + \epsilon_m}\,.\,\frac{JM}{R}\left(\frac{dQ}{dT} - \frac{L}{T}\right)\right]$, and $c = (1 + \epsilon_p)\left[\frac{R}{JM}\left(\frac{T}{F}\frac{dF}{dT} - 1 - \epsilon_p'\right) + \frac{1}{1 + \epsilon_m}\left(\frac{dQ}{dT} - \frac{L}{T}\right)\right]$. Experimental results are given for water-vapour ranging from the saturated to the superheated state. Here for the saturated vapour γ passes through a maximum towards 140°, while C and c increase more and more rapidly from 100° to 160°. These variations appear to be the resultant of two effects. Elevation of temperature at constant pressure, lowers γ and increases C and c; while all three increase with pressure at constant temperature within the range considered. A discussion of the data of Holborn, Henning, Knoblauch, Jakob, and Austin concludes the paper. H. H. Ho.

1105. *Latent Heat of Freezing for the Rare Gases in Liquid Form.* **J. Narbutt.** (Phys. Zeits. 22. pp. 52–53, Jan. 15, 1921.)—This paper gives an approximate calculation of the heat rendered latent in the solidification of liquefied rare gases. If the latent heat of fusion per gm. atom ($A\rho$, in kg. cals.) is divided by the absolute temperature of fusion (Θ, at atmospheric pressure) for different elements, it is seen that these quotients, for the elements of a sub-group of the periodic system, only exhibit small deviations from a single value. The more accurate the determinations of the latent heat of the elements, the more nearly are the above quotients found to agree. For Na, K, Rb, Cs the value of $A\rho/\Theta$ is 0·00168; for Zn, Cd, Hg it is 0·0025, and for Cl, Br, I the value is 0·0048. It appears very probable that the quotients for all elements of the principal group have the same value, and so from known elements the latent heat of other elements can be calculated if their freezing-points are known. According to Eucken [Abs. 514 (1917)] the heat of fusion of argon per gm. atom is 0·268 cals., and the absolute freezing temperature is 83·8°, whence the constant $A\rho/\Theta$ is 0·0032. The following table gives the calculated values for the latent heat of fusion of the other rare gases. In the case of helium, whose freezing-point is not known, an approximation to the upper limit for $A\rho$ is given. If the values so found are reliable, it appears that the heat of fusion in the case of helium is exceptionally low, and less than that of any other known substance.

Substance.	Θ.	Aρ, Cals.
Helium	$<1·15°$	$<0·004$
Neon	24	0·08
Argon	84	(0·268)
Krypton	104	0·33
Xenon	133	0·43
Niton	202	0·65

A. W.

1106. *Observations of the Temperature during Solidification.* **H. C. Burger.** (K. Akad. Amsterdam, Proc. 23. 5. pp. 691–704, 1921.)—When into a supercooled liquid in a cylindrical tube a seed of the solid substance is inserted, the boundary plane of the solid substance moves with uniform velocity. This velocity (linear velocity of crystallisation) has been measured by many investigators as a function of the temperature of the surroundings. No measurements, however, have been made of the temperature prevailing during the solidification in the two phases and at their boundary plane, though it is the measurement of this temperature which is of great importance for a true insight into the process of solidification. More than once the opinion has been expressed, that at the boundary plane solid-liquid the melting-point temperature would prevail, but no grounds have been adduced in support. The author's observations are to the contrary, and his experimental conditions are carefully described, as also the method of observation. Salol was the substance employed, and its advantages are summarised as: slow rate of crystallisation; easily supercooled; convenient melting-point of 42° C. The sources of the errors which may enter are considered in detail. A full discussion is given of the results of the measurements guided by theory. The quantities required to be measured are: the linear velocity of crystallisation of salol at different temperatures of the thermostat and in tubes of different known internal and external dimensions; the specific heat of the solid substance and of the liquid; the melting-heat of salol; the density and thermal conductivity of the solid substance and of the liquid. The methods and conditions for these measurements are given in full. The rise of temperature was measured as a function of the time, the results being plotted on curves which are included in the paper. The registered curves are asymmetrical, the ascending branch (temperature in the liquid phase) being steeper than the descending (temperature in the solid phase). This difference decreases with the fall in velocity of crystallisation. Theory is shown to account for these observed facts. The functional relation between velocity of crystallisation and boundary temperature is found to depend on the nature of the substance, and not on the peculiarities in the method of observation. **H. H. Ho.**

1107. *Theory of Radiometer Action.* **G. Laski and F. Zerner.** (Zeits. f. Physik, 3. 4. pp. 224–242, 1920.)—A mathematical treatment dealing particularly with the case of spheres whose dimensions are of the same order as the mean free path of the gas. The effect of the size of the spheres and of the wave-length of the incident light is also discussed. **A. W.**

1108. *Negative Radiometer Effect and Photophoresis.* **W. Gerlach.** (Zeits. f. Physik, 2. 3. pp. 207–212, 1920.)—Describes radiometer observations made with thin plates of selenium and molybdenum glance. Among other things, the results showed that the negative effect changes to the positive effect if the red and ultra-red rays, for which the substance investigated is transparent, are cut off. In the experiments, only such effects were observed as would be obtained with pure radiometer action due to heating by the radiation absorbed. [See Abs. 1188 (1919) and 589 (1920).] **A. W.**

1109. *Similarity between Carbon Dioxide and Nitrous Oxide.* **A. O. Rankine.** (Roy. Soc., Proc. 98. pp. 369–374, Feb. 2, 1921.)—One of the most remarkable evidences in favour of the Lewis-Langmuir theory of molecular constitution [see Abs. 991 (1919)] is the close degree of equality between nearly all of the physical constants of the two compounds, carbon dioxide and nitrous oxide. This identity is attributed by Langmuir to the arrangement of external electrons being the same for the molecules of the two gases in question. It is the purpose of the present communication to show that an appeal to the kinetic theory of gases, in conjunction with what is now known from W. L. Bragg's work regarding the dimensions of atoms [see Abs. 21 (1921)], produces substantial additional evidence in support of the Lewis-Langmuir views. In particular it is shown that the molecules of CO_2 and N_2O behave not merely as though they had the same size and shape, but as if each of them had an external electron arrangement practically the same as that of three neon atoms in line and contiguous. This arrangement is precisely that which Langmuir suggests, and is represented in the paper by a diagram. The data which W. L. Bragg has derived from X-ray crystal measurements allow of the computation of the distance apart of the centres of two neon atoms when their outer electron shells are contiguous. A hypothetical molecule of three neon atoms with their centres in the same straight line, and successive centres $1 \cdot 30 \times 10^{-8}$ cm. apart, is constructed, and its kinetic behaviour compared with that of the molecules of CO_2 and N_2O. An alternative model of the shape of the molecule has also been considered—namely, to treat it as an ellipsoid of revolution. **H. H. Ho.**

1110. *The Rectilinear Diameter of Hydrogen.* **E. Mathias, C. A. Crommelin, H. K. Onnes.** (Comptes Rendus, 172. pp. 261–263, Jan. 31, 1921.)—The present paper contains a study of the density curve for hydrogen between the critical point (– 239·91 C.) and the boiling-point (– 252·76 C.). Previous work had determined the densities of the liquid between the boiling and solidification points [see Abs. 974, 975 (1917)]. The apparatus employed was very similar to that in previous experiments, except for a modification of the cryostat in which superheated hydrogen vapour was used, this being obtained by evaporation of the liquefied gas, which was then heated by an electric current. Experimental details are given, and a table of data is included. The deviations found are so small as to lead to the conclusion that hydrogen obeys the law of the rectilinear diameter. Three points, however, of the diameter nearest to the critical point give more considerable divergences, the largest being 1/200. Nitrogen has shown a larger divergence of 1/50, while that for argon is still more pronounced. An explanation of these anomalies is not attempted owing to the unknown nature of the experimental errors. The data obtained together with the saturated vapour tensions permit of the calculation of the heat of vaporisation L and of $m' - m = dL/dT - L/T$, where m and m' are the specific heats of the liquid and vapour saturated at T°. (Erratum: *ibid.*, p. 628, March 7, 1921.) H. H. Ho.

1111. *Genesis of Quantum Theory*. **M. Planck.** (Nature, 106. pp. 508–509, Dec. 16, 1920. Address delivered on occasion of receiving Nobel Prize for Physics.)—The quantum theory arose from the search into the nature of the relation between the energy of radiation and its wave-length and temperature. Rayleigh had stated it as it should have been in accordance with existing physical theory in a formula agreeing with experiment for the longer waves, but in absolute conflict therewith for the visible and ultra-violet waves. Wien's formula, mainly empirical, agreed well with observation throughout the visible spectrum. The author started from Kirchhoff's suggestion that determination of the emission and absorption for a single ideal radiating substance would give the required relation. Reasoning dynamically, he was led to Rayleigh's formula. He then sought a solution thermodynamically, and, although thermodynamics is not concerned in the solution, his search in this direction led to success, through his study of the second derivative of the entropy with respect to the energy, the reciprocal of which was in Wien's formula proportional to the energy. This, however, was obviously accidental, since in Rayleigh's formula it was proportional to the energy squared. The happy thought of combining these results led empirically to the true formula. In seeking a theoretical basis therefor, he turned towards the more fundamental interpretation of entropy in terms of probability, indicated by the kinetic theory of matter. Proceeding on the lines of the probability calculus, which deals, not with continuous, but solely with discrete, quantities, it was necessary, as a provisional mathematical artifice, to assume the existence of atoms of energy which, proceeding to the limit, would ultimately vanish. The solution presented itself, however, not at the limit, but at a definite stage of the theory, which was determined by its agreement throughout with observation. In the course of these experiments there emerged two universal constants, one of which led to the earliest satisfactory values of the charge of the electron and the associated constants, while the other was what is now known as the quantum. Dealing with the successful applications of the quantum theory, he naturally places Bohr's spectrum theory in the forefront, dealing subsequently with the photoelectric effect, specific heats of gases and of solids at low temperatures, etc. With respect to the profound difficulties of the quantum theory, involving the physicist in the apparent necessity of provisionally accepting mutually inconsistent assumptions of fundamental character, the author has little encouragement to offer. He makes some speculative suggestions as to directions in which a solution may be found, and all such suggestions will be welcomed by physicists as pointing out avenues worthy of exploration. But the view to which he gives expression, that the quantum theory may be regarded as being now much in the state in which Römer left the theory of light, is not an encouraging one. G. W. de T.

1112. *The Theorem of Corresponding States and the Quantum Theory for Gases and Liquids.* **A. Byk.** (Phys. Zeits. 22. pp. 15-20, Jan. 1, 1921.)—The author opines that the quanta effects of the fluid state will be shown much more clearly when states of high density approximating to the liquid condition are considered instead of the dilute gases almost exclusively investigated hitherto. In order to avoid the limitation imposed by the method of oscillations, the author utilises the Planck structure theory of the phase space, and obtains a new standpoint for the quantum theory which is not limited to the partial differentials of the free energy with respect to the volume, but becomes of general application. According to Onnes, in the sphere of the equation of state, classical mechanics by means of the principle of mechanical similarity leads to the theory of corresponding states. From experience, however, this is a law limited to substances possessing a high critical temperature, while those of low critical temperature deviate considerably therefrom. The author suggests that this deviation may show the incompatibility of the principle of similarity with the quantum theory, and proceeds to compare two mechanically similar molecular systems. Data from 41 substances are utilised for testing the author's theory. It is shown that the classical theory of corresponding states appears as a limiting case of the quantum theory in the same sense as the classical Rayleigh-Jeans radiation law is a limiting case of Planck's quantum radiation law. H. H. Ho.

1113. *Internal Friction (Viscosity) of Hydrogen at Low Temperatures; Confirmation of Nernst's Theoretical Deductions.* **P. Günther.** (Preuss. Akad. Wiss. Berlin, Ber. 36. pp. 720-726, 1920.)—Certain conclusions have been derived by Nernst from the distribution theory of gases, which necessitate data for the internal friction of gases at very low temperatures. These conclusions include a force law between the molecules inversely proportional to the mass and to the third power of the distance apart. From this hypothesis a very simple law for the decline in the internal friction of gases at very low temperatures may be derived, which should be capable of experimental verification. Only the data of Onnes and Weber, using the transpiration method, and Vogel, who employed an oscillating disc, are available for hydrogen and helium [see Abs. 1187 (1914)]. Below 21° abs., however, no data are available, and the present paper contains an account of experiments on the internal friction of hydrogen at the temperature of boiling hydrogen. Vogel's method of the oscillating disc is employed, and the experimental arrangements are briefly described. The results obtained for hydrogen are quite in conformity with Nernst's theoretical deductions. H. H. Ho.

SOUND.

1114. *Propagation of Sound in Partly-dissociated Gases.* **A. Einstein.** (Preuss. Akad. Wiss. Berlin, Ber. 19. pp. 380–385, 1920.)—Direct determinations of the reaction velocities in gases being difficult owing to the catalytic influences of the walls of the containers, the author suggests that these rates be deduced from experiments on the propagation of sound in partly-dissociated gases. When the volume of a partly-dissociated gas is adiabatically changed at so rapid a rate that there is no appreciable chemical reaction, the gas will behave like a mixture. When the change is made slow so that the process practically becomes a sequence of chemical equilibria, the relation between pressure and density will be altered and the compressibility of the mixture will be decreased. The velocity of sound will hence, with the frequency of the changes, increase from an initial value to an upper limit, there being for intermediate frequencies a time lag between the pressure curve and the density curve while mechanical work is transformed into heat. The paper is confined to a mathematical deduction of the propagation of sound in a gas, partly dissociated after $J_2 \rightleftarrows J + J_1$. The author starts from Euler's equation for the movement of a plane wave :—$\partial\pi/\partial x = \rho\partial^2 u/\partial t^2$, where π is the deviation of the pressure from the equilibrium value p, ρ the equilibrium density, and u the elongation of a particle of air in the direction of the X axis; the compression Δ will be $\Delta = -\rho\partial u/\partial x$. The ratio π/Δ is deduced from cyclic-adiabatic volume changes, and the dissociation is assumed to be a reaction of the first order, not caused directly by collisions between the molecules. The connection between sound velocity and reaction velocity was pointed out by F. Kentel (Dissertation, Berlin, 1910) when experimenting on the dissociation of N_2O_4. H. B.

1115. *Acoustic Impedance and its Measurement.* **A. E. Kennelly** and **K. Kurokawa.** (Am. Acad., Proc. 56. pp. 3–42, Feb., 1921.)—If an alternating mechanical force F be applied to a disc fitting frictionless in a smooth tube, an alternating velocity $\dot{x}$ will be set up in the air in the tube. Z, the total acoustic impedance to velocity of the fluid in the tube at the disc is defined as $F/\dot{x}$. Acoustic impedance is the plane vector sum of acoustic resistance (which absorbs and dissipates energy) and acoustic reactance (which stores and releases energy without dissipation). It is a plane vector quantity expressible in complex numbers. The impedance in the case described will be proportional to the cross-sectional area of the tube. The impedance per unit area is the acoustic impedance density. It is shown that if the velocity $\dot{x}$ is not the same at all parts of the disc the r.m.s. value may be taken. A method of measurement of acoustic impedance, based on the measurement of the motional impedance of a telephone receiver is described [see Abs. 490B (1917)], and is applied to the measurement of the impedance of the air column in a closed tube of varied length. The technique of this method is dealt with, and diagrams giving the results of the measurements are included. The variations in impedance as the air column is lengthened are periodic and conform fairly well with the expression $Z_0 \tanh \delta_A$, where Z_0 is the surge impedance of the column, or the acoustic impedance offered to the particular frequency by an indefinitely great length of tube, and δ_A is the "position angle" at the sending end of the tube as the length is varied. The case offers a very complete analogy, which is discussed in detail in an appendix, to that of an electric line transmitting alternating current. The effects of different apertures in the plug closing the tube and of pressing the receiver against the ear are studied. It is suggested that the methods described have possible applications to architectural acoustics. A bibliography of the subject is appended to the article. W. H. G.

1116. *Ballistic Phonometer; Limit of Audibility.* **A. Stefanini.** (N. Cimento, 19. pp. 5–30, Jan., 1920.)—Describes further experiments with Banerji's ballistic phonometer [see Abs. 1053 (1916)]. Measurements were made with various angles of deflection of the balls, and with balls of different weights. The limit of audibility was found to be of the order of 8×10^{-5} erg per cm.^{2} per sec. J. W. T. W.

1117. *Notes on the Theory of Vibrations.* (1) *Vibrations of Finite Amplitude.* (2) *A Theorem due to Routh.* **W. J. Harrison.** (Cambridge Phil. Soc., Proc. 20. pp. 83–87, Sept., 1920.)—Mathematical.

1118. *Systems with Propagated Coupling.* **A. W. Porter** and **R. E. Gibbs.** (Phil. Mag. 41. pp. 432–440, March, 1921.)—In the majority of electrically-coupled circuits the two circuits are so close together that the time of propagation of the mutual action can be neglected. For great distances of separation, or for very high frequencies, this would no longer be true. When the coupling is of a mechanical nature (instead of electrical), and the actions are propagated with the speed of sound, the entry of time would have to be considered for even quite small frequencies at moderate distances. For example, with a frequency of a thousand per sec. through air, even 30 cm. separation would change the phase of action through a complete period. A fairly simple case in which acoustic coupling comes into play in this way, is that of a microphone transmitter and a telephone receiver coupled electrically through a valve set, and simultaneously, acoustically, through the intervening air. By such an arrangement a set of maxima and minima of mutual action can be obtained at different distances. A number of similar cases are worked out mathematically. E. H. B.

1119. *Reed Pipes and Valve Transmitters.* **H. Vogel** and **M. Wien.** (Ann. d. Physik, 62. 7. pp. 649–665, Aug. 4, 1920.)—A theoretical paper in which is developed the analogy between the vibrations of reed pipes and a three-electrode valve transmitter, each being treated as an example of coupled vibrations. The close similarity of the two cases is illustrated by thirty figures and graphs. E. H. B.

1120. *Sound Transmitter and Detector,* III and IV. **W. Hahnemann** and **H. Hecht.** (Phys. Zeits. 21. pp. 264–270, May 15, and pp. 426–430, Aug. 15, 1920.)—These papers follow on earlier ones [see Abs. 1078 (1919)], in which the electromagnetic theory; in the present two, the sound transmitter and receiver are respectively dealt with. In the form of sender here in use we have a partial inversion of the Bell telephone receiver, that is, a magnet is fixed near a membrane on the back of which is carried a coil. On passing an alternating current through this coil the membrane is set in oscillation, and sound emitted. The same apparatus is then considered as a detector of sound waves received on its membrane. Experiments with the device, both as a sender and as a receiver, are in agreement with the theory developed. **E. H. B.**

1121. *Theory of Cutting Tones.* **F. Krüger.** (Ann. d. Physik, 62. 8. pp. 673–690, Aug. 20, 1920.)—A vortex theory of the generation of cutting tones is here developed. Such tones are produced by the rush of fluid past sharp edges, and in the present paper the theory is established experimentally by use of water coloured with potassium permanganate as the fluid, the edges being the 52° angles of two opposed prisms. Photographs are reproduced showing the motions; these confirm the theory [see Abs. 2647 (1904)]. **E. H. B.**

1122. *Nature of Vowel Sounds.* **E. W. Scripture.** (Nature, 106. pp. 632–634, Jan. 13, and pp. 664–666, Jan. 20, 1921.)—Describes the analysis of vowels by a device giving an enlarged trace on smoked paper from a gramophone disc. Some of the curves thus obtained are reproduced and another is analysed both into harmonic and into inharmonic components. It is found that not in speech alone but in song also the pitch of a vowel is continually varying. Another device is illustrated, this being for the manufacture of vowels. A blast of air passes through the holes of a disc siren into a water resonator consisting of a cubical box with wire frame covered with a layer of absorbent cotton soaked in water. The extreme complexity of the vowels is made very clear. It is felt that some analysis is needed which will accomplish for compound vibrations whose components are *damped* sinusoids, what Fourier's analysis has done for those containing only *sustained* sinusoids. **E. H. B.**

1123. *Propagation of Sound of Gun Fire to Great Distances.* **M. Collignon.** (Comptes Rendus, 172. pp. 213–215, Jan. 24, 1921.)—Gives tables of observation as to successive maxima and minima of sounds audible at various distances from the source, together with details as to the winds prevailing at the times in question. **E. H. B.**

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

1124. *Absolute Significance of Maxwell's Equations.* **F. D. Murnaghan.** (Phys. Rev. 17. pp. 73–88, Feb., 1921.)—*Elementary Proof of a Generalised Stokes' Theorem for Hyper-space.*—After giving precise definitions of the ideas of integrals extended over lines, surfaces, and hyper-surfaces in a space of arbitrary metrical character, the author presents an elementary proof of a generalised Stokes' theorem which reduces the integral over an open hyper-surface to an integral over the closed surfaces which bound it.

Statement of Maxwell's Equations as Integrals over Hyper-surfaces, brings out their physical significance more clearly as relations between surface integrals and hyper-surface integrals. It is explained how this form of statement lends itself at once to the methods of the absolute differential calculus.

Electromagnetic Potential.—The *existence* of this potential, which is a hyper-space combination of vector and scalar potentials, is proved and the normal form of its *line integral over any open curve* is given (1) for any electromagnetic field where $(\overline{E}.\overline{B}) = 0$, and (2) for any other field.

AUTHOR.

1125. *Theory and Calculation of Variable Electrical Systems.* **J. R. Carson.** (Phys. Rev. 17. pp. 116–134, Feb., 1921.)—Variable electrical systems are defined as those in which either the circuit elements (resistance, inductance, or capacity) are explicit time functions, or those in which the relation between current and applied e.m.f. is non-linear. In the present paper, the *theoretical methods of solution* of " invariable systems " are extended to include variable systems by integral equations of the Volterra type. A number of representative problems are worked through to indicate the appropriate mathematical procedure and the applicability of the method to both transient and steady state phenomena.

AUTHOR.

1126. *Some Applications of the Method of Images.* **J. Kunz, P. L. Bayley, C. M. Hebbert.** (Phys. Rev. 17. pp. 147–156 and 157–160, Feb., 1921.)—*Solution of some Electrostatic Problems by the Method of Images.* (*a*) *Charged Wire between Two Parallel Plates.*—In Part I the first two authors obtain expressions for the potentials at any point between an infinitely long charged wire and two conducting infinite planes parallel to it, for the surface density of the induced charge at any point on the plates, and for the capacity per unit length of such a condenser. These expressions contain only circular and hyperbolic functions. (*b*) *Charged Wire Inside an Infinite Rectangular Tube.*—In Part II, the potential at any point inside the tube is obtained by a single infinite summation of the potentials due to each of a singly infinite set of images as given by the expression in Part I. Thus, although the problem is essentially one of doubly periodic functions, the solutions appear in circular and hyperbolic functions. Comparing a square tube with a circular tube of the same capacity, each with a small wire of a given size through its centre, the square tube has the larger perimeter. Tables are given showing the variation of the capacity of a certain rectangular tube with the size of the wire at its centre and with the position of a certain sized wire. (*c*) *Two or Four Charged Wires Inside a Rectangular Tube.*—In the case of certain symmetrical positions this problem can be solved immediately from the preceding results.

Distribution of Potential around a Charged Wire within a Rectangular Tube as Determined by the Method of Images.—Hebbert derives the general equation for potential, given by Kunz and Bayley in the preceding paper, directly from Euler's infinite product expansion for the sine, thus avoiding the use of elliptic functions. Equipotential lines and lines of force are shown for two cases, namely, a square and a rectangular tube; also curves giving the fall of potential along certain important lines.

AUTHORS.

1127. *Electrification of an Insulated Lens, Treated by the Stream-force Function; and Allied Problems.* **G. Greenhill.** (Roy. Soc., Proc. 98. pp. 345–359, Feb. 2, 1921.)—The author's chief object is the calculation of the Stokes' stream-current or force-function, S, representing uniaxial surfaces having meridian section of a line of force, orthogonal to the uniaxial potential function, V, with special reference to the electrical problems discussed by H. M. Macdonald (London Math. Soc., Proc. 26, 1895), in a body bounded by spherical surfaces, as a lens. L. H. W.

1128. *Electricity and Matter.* **E. Rutherford.** (Engineering, 111. pp. 296–297, March 11; 345–347, March 25; and pp. 379–381, April 1, 1921. Lectures delivered before the Royal Inst.)

1129. *Theory of the Two-Plate Condenser.* **R. Serini.** (Accad. Lincei, Atti, 29. ii. pp. 34–37, July, and pp. 257–261, Oct., 1920.)—A mathematical discussion of the problem of an electric condenser consisting of two coaxial and equal circular discs. It is shown that if a/l be less than $\frac{1}{2}\pi$ a solution can be obtained in the form of a convergent series, l being the separation of the discs and a the radius. The problem is also soluble when $a/l = \infty$. J. W. T. W.

1130. *Measurements of Ionisation and Ion Mobility while Flying.*—**A. Wigand.** (Phys. Zeits. 21. p. 571, Nov. 1 and 15, 1920, and 22. pp. 36–46, Jan. 15, 1921.)—Full details of the apparatus carried and of the methods of measurement are given, together with the actual results obtained during four ascents in a free balloon, one up to 4·1 km., and two flights by aeroplane, one up to 5·2 km. Ionisation $E_{\pm}$ and conductivity $\lambda_{\pm}$ were observed in the balloon and the mobility $v_{\pm}$, corresponding to the pressure b at which the observations were made, was calculated from $\lambda_{\pm} = E_{\pm} . v_{\pm}$. Mobility was further reduced to standard pressure, $v'_{\pm} = (b/760)v_{\pm}$. Observations of temperature, pressure, and humidity including cloud, were made at the same time and the upper winds were observed independently from the ground. The vertical variations of each element, electrical and meteorological, are represented diagrammatically for easy comparison. Ionisation at a given height shows marked variations from day to day. An increase in conductivity with height has hitherto been observed and is here confirmed. In the lower layers, with water-vapour and cloud, ionisation is constant or decreases upwards, above which there is a rapid rise and then a slower increase. At these greater heights $E_+ > E_-$ except during thunder conditions. v'_+ increase quickly to double their value in the lower layers; above this, at least up to 3 or 4 km., there is little variation. As a rule, at the same height, $v_- > v_+$. During thunderstorms, however, $v_+ > v_-$ and $E_- > E_+$. Within the heights reached the influence of solar radiation or ionisation is not to be assumed effective from sunrise till at least two hours thereafter.

During the aeroplane flights ionisation was observed and the Ebert ion-counter was found to give good results when adapted to these conditions. M. A. G.

DISCHARGE AND OSCILLATIONS.

1131. *Formation of Negative Ions in Air.* **L. B. Loeb.** (Phys. Rev. 17. pp. 89–115, Feb., 1921.)—*Mobility of Negative Ions in Air at Low Pressures.*—The purpose of the experiments was to decide between the two theories of the formation of negative ions, proposed by Wellisch and by J. J. Thomson. The carriers were generated as photo-electrons by focusing ultra-violet light on one plate of a condenser at grazing incidence, thus eliminating stray light effects. Great care was used to secure pure air. The *curves* obtained agree in general with the results of previous investigators; they show anomalous mobilities below critical pressure which was found to vary with the frequency of commutation of the e.m.f. No "free electrons" of the Wellisch type were observed. A repetition of the Wellisch experiments with photo-electrons showed that the "free electrons" were really a type of carrier which started as electrons but attached themselves to molecules in the measuring field, as the Thomson theory demands. To *test the Thomson theory*, curves were computed assuming certain values for the constants. Theoretical and observed curves are similar in shape; in particular, the inflections near the low-voltage end fall fairly closely together. It is also shown that the Wellisch *results* are in accord with this theory. The "*chance of negative ion formation*" *constant*, $1/n$, comes out about $1/(2 \cdot 5 \times 10^5)$ *for air*. As $1/n$ is 0 for *nitrogen*, and as $1/n$ in *oxygen* is about 1/50,000, it is concluded that electrons attach themselves to the oxygen molecule in air in order to form ions. AUTHOR.

1132. *Secondary Electron Emission from Copper Surfaces.* **I. G. Barber.** (Phys. Rev. 17. pp. 322–338, March, 1921.)—The method used was to measure the current flowing to the bombarded plate as a function of the grid potential. By using sufficiently low pressures the ionisation effect was made negligible. (1) *The coefficient of secondary emission* was found to increase somewhat with the energy of the primary electron *up to 500 volts* but never exceeded 1·5 per electron; the coefficient was increased by *heat-treating the plate*, and was greatly decreased by raising the *temperature of the plate*. (2) *The energy* of the secondary electrons was always less than that corresponding to a fall through 5 volts, yet owing to the roughness of the surface an accelerating potential of about 10 volts is required to release most of the secondary electrons from the plate. (3) As to the *origin* of these rays, the fact that their max. energy is always less than the energy of the primary rays and the shape of the curves obtained both indicate that the secondary electrons are not reflected electrons.

Reflection of electronic rays with energy below 500 volts, from a copper surface seems to be zero, or at least small. AUTHOR.

1133. *Potential of Excitation for Electrons in a Mixture of the Vapours of Sodium and Potassium.* **A. Campetti.** (Accad. Lincei, Atti, 29. ii. pp. 385–388, Dec. 19, 1920.)—The apparatus adopted in these experiments is similar to that used by Franck and Hertz, and is briefly described; the experiments are, however, considered as of a preliminary nature and should be carried out under better conditions. Certain modifications are suggested. A. E. G.

1134. *Current Density in the Crater of the Carbon Arc.* **N. A. Allen.** (Phys. Soc., Proc. 33. pp. 62–68; Disc., 68–69, Feb., 1921.)—In this work the Y-arrangement of carbons due to Forrest was used. This facilitated accurate measurement of crater area. The carbons used were solid special "Electra" of diameter 6 mm. For currents up to 10 amps. the crater area was directly proportional to total current, thus maintaining a constant current density, namely, $0{\cdot}746$ amp./mm.^{2}. AUTHOR.

1135. *Luminosity of Mercury Vapour Distilled from the Arc in Vacuo.* **N. H. Ricker.** (Phys. Rev. 17. pp. 195–226, Feb., 1921.)—*Afterglow of Mercury Vapour from an Arc in Vacuum.*—(1) The *effect of an electric field on the spectrum* was studied. It was found that charged grids decreased the luminosity without changing the colour; but when, under certain conditions, the luminosity was increased, there was a change in the relative intensity of the lines. (2) The *velocity of the vapour was measured by a stroboscopic method.* The luminosity was decreased intermittently at a known frequency and the resulting "puffs" as they moved along the tube were observed stroboscopically. From this velocity and the rate of distillation, the density of the vapour was computed. (3) *Decay of luminosity along the tube* was observed. (4) *Theoretical discussion* of these results leads to the conclusion that recombination of the positive and negative ions produced by the discharge, is the most probable cause of the afterglow. AUTHOR.

1136. *The Discontinuous Discharge in Relation to the General Study of Electric Discharges.* **G. Valle.** (N. Cimento, 18. pp. 205–265, Nov., 1919. Elettrotecnica, 7. pp. 246–248, May 15, 1920.)—After a short introductory note this lengthy paper is divided into three sections. In the first part the influence of the primary circuit upon the discontinuous discharge is considered under the following heads: (1) Fundamental phenomena; (2) the various types of discharge; (3) influence of the capacity and of the resistance of the circuit upon the type of discharge; (4) characteristics of the transition from one to the other kind of discharge; (5) effects of the variations of e.m.f.; (6) difficulty in distinguishing the continuous from the discontinuous discharge. In the second part the characteristics of the passage of electricity in a Geissler tube are dealt with as follows: (1) Various aspects of the passage of the electric current in the gas; (2) determination of the electrical condition of gas through which an electric current is passing; (3) characteristics of the electric discharge; (4) extension of the idea of the discharge. In the last section the following points are considered: (1) Typical form of the dynamical characteristics for the three kinds of discontinuous discharge; (2) discontinuous discharge of the first kind; (3) discontinuous discharge of the second kind and group discharges; (4) irregularities in the phenomena; (5) conclusions. A. E. G.

1137. *Impulsive Sparking Voltages in Small Gaps.* **J. D. Morgan.** (Phil. Mag. 41. pp. 462–469, March, 1921.)—The paper deals with the lag which occurs when a spark-gap is operated by an oscillatory or impulsive voltage. Using an induction coil it is shown by experiment that the sparking voltage for a given gap varies with the current broken in the primary, an increase in one being accompanied by an increase in the other. The time which elapses between the breaking of the primary current and the occurrence of the spark, decreases with increase in current. These results were obtained using gaps from 0·01 to 0·06 in. in width.

In any one of the voltage–current curves, the first point, *i.e.*, the one at which sparking occurred with the least primary current, was always the most definite. Irregularities of spark frequency, but not in sparking voltage, were noticed at this point. As the primary current was increased, the sparking became more regular, but the sparking voltage less regular. These irregularities are due to variations in the ionisation of the gap prior to the passage of the spark. The phenomena are more pronounced with pointed electrodes than with spheres or flat plates.

It is concluded that the impulsive sparking voltage for a given gap depends on (*a*) the rate of rise of voltage, (*b*) the initial ionisation of the gap, (*c*) the time of application of the voltage. N. W. M.

1138. *Characteristic Curve of Spark Discharge.* **G. Valle.** (N. Cimento, 18. pp. 155–171, Oct., 1919.)—Tables are given of the p.d. and current intensity, and the relation between these is also shown diagrammatically. It is concluded that for discharges which are undoubtedly discontinuous the relationship $dV/dI < 0$ always holds. A. E. G.

1139. *A Sodium-Vapour Discharge Tube; Method of Producing a Source of Na Radiation.* **F. H. Newman.** (Phys. Soc., Proc. 33. pp. 70–72; Disc., 72, Feb., 1921.)—A simple method of producing a bright source of sodium radiation is described. A discharge tube of quartz, having a pool of Na-K alloy as one electrode, and an iron rod as the other electrode, is utilised. The sodium vapour is produced by gently heating the lower part of the tube, containing the alloy, over a ring gas burner concentric with the tube. When a discharge is passed, a bright yellow light is emitted. This light consists almost entirely of the D-lines. Any gases present in the tube are absorbed by the alloy while the discharge is passing. No continuous pumping is necessary to keep the tube exhausted, and the experiment works best when the temperature of the sodium vapour is 250° C. AUTHOR.

1140. *Electric Spark; Actinic Value Compared with that of Arc and the Sun.* **L. Bull.** (Comptes Rendus, 172. pp. 807–808, March 29, 1921.)—Experiments were carried out to compare the actinic value of the light from an electric spark with that from a carbon arc. The sparks took place between Al points 1·5 mm. apart, the capacity being 0·0005 microfarad. Such sparks are sufficient for instantaneous photography, and give a small luminous region not surrounded by an aureole as with more energetic sparks. Identical optical systems were employed to project side by side on a sensitive surface, images of the two sources. The ratio of the duration of the spark to the duration of exposure for the arc to give the same degree of blackening of the sensitive surface was taken to be the inverse ratio of the intensities per unit surface of the two sources. The results obtained lead to the conclusion that the actinic value for such a spark is at least 160 times that of the arc, or 16 times that of the sun, assuming for this a value 10 times that of the arc. A. W.

1141. *Damped Electric Oscillations.* **R. B. Abbott.** (Phys. Rev. 17. pp. 482–492, April, 1921.)—*Historical.*—Logarithmic and linear damping in electric circuits. A summary of previous work is given with reference to important original papers.

Damped Electric Oscillations; Solutions of Differential Equations for Four Types of Oscillations: (1) *Simple Harmonic;* (2) *Logarithmically Damped;* (3) *Linearly Damped;* (4) *Combined Logarithmically and Linearly Damped.*—The mathematical treatment is based upon the analogy between the dynamical and electrical differential equations of motion. A simplification results by this method in the solution of the fourth case. AUTHOR.

1142. *Quickness of Response of Current to Voltage in a Thermionic Tube.* **D. Owen and R. M. Archer.** (Phys. Soc., Proc. 33. pp. 104–114; Disc., 114–115, Feb., 1921.)—Steady voltages were applied between the hot and cold electrodes of a thermionic tube, for intervals of time which could be varied from 0·00001 sec. to a minute or longer. The mean current during the interval was measured by the Wheatstone bridge, using a null ballistic method. Two types of thermionic tube were employed, one at a comparatively high gas pressure, the other at a far higher degree of exhaustion. It is found that on applying the voltage the initial rise of current to its maximum is followed by a fall, the rate of which diminishes with time. In the tube at the high gas-pressure the effect is considerable, and the final value of current may be less than half the initial value. In the case of the tubes at lower gas pressure the fall, though sensible, is far less pronounced, say, 3 or 4 %. An experiment is described showing that whatever the change of conditions causing the observed fall may prove to be, this fall is not attributable merely to the high temperature of the filament but is conditional on the thermionic current being permitted to flow. The results point to the practical conclusion that in order to avoid phase difference between current and applied voltage, and consequent distortion, at telephonic frequencies, of signals transmitted through a thermionic tube, the vacuum should be as high as possible. AUTHORS.

1143. *Method of Demonstrating the Retroactive Property of a Triode Oscillator.* **E. V. Appleton.** (Phys. Soc., Proc. 33. pp. 100–103; Disc., 103, Feb., 1921.)—The author, following Vallauri, gives an approximate treatment of the conditions which gives rise to retroaction between the grid and anode circuits of a triode valve, and describes an arrangement of circuits whereby the property can easily be demonstrated to a large audience. AUTHOR.

1144. *Stability Conditions in Vacuum Tube Circuits.* **R. D. Duncan, Jr.** (Phys. Rev. 17. pp. 302–314, March, 1921.)—*Condition for Sustained Oscillations in Vacuum Tube Circuits.*—After reviewing the fundamental requirements for such oscillations in any three-electrode vacuum tube circuit, the fundamental equation for the plate current of a tube with a linear volt-ampere characteristic: $i_p = (v_p + \mu v_g) R_0$ is differentiated, $-dv_p/di_p$ is put equal to the load resistance in the plate circuit R_2, and thus the equation $\mu = -(1 + R_0/R_2)dv_p/dv_g$ is obtained as a general relation between the constants of any oscillating circuit (R_2), the internal resistance of the plate-filament path R_0, the amplification constant μ, and the derivative of the plate voltage with respect to the grid voltage. This expression is evaluated for five standard types of circuit; Hartley, Colpitts, Meissner, tuned-plate and tuned grid; and it is experimentally verified for the first two. AUTHOR.

1145. *Thermionic Current between Parallel Plane Electrodes; Velocities of Emission Distributed according to Maxwell's Law.* **T. C. Fry.** (Phys. Rev. 17. pp. 441–452, April, 1921.)—The electrical equations applying to this problem are developed without neglecting the distribution of initial velocities, which in the first place is allowed to be entirely general. *Maxwell's distribution of velocities* is then considered in detail and a complete solution obtained.

Curves from which to compute the space current when Maxwell's distribution applies are presented, together with an example illustrative of their use. Curves are also included showing the *deviation of the current–voltage relation from the 3/2-power law*; the variation of the *minimum potential between the electrodes* with plate voltage, and also the variation with plate voltage of *the distance between the kathode and the point at which this minimum potential occurs.* AUTHOR.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

1146. *Electrical Resistance of Metals; Effect of Pressures up to 12,000 Atmos. in Temperature Range 0–275° C.* **P. W. Bridgman.** (Am. Acad., Proc. 56. pp. 61–154, Feb., 1921. Phys. Rev. 17. pp. 161–194, Feb., 1921.)—*Electrical Resistance of Eighteen Elements.*—The first paper is the complete account [see Abs. 523 (1921)] of an extensive series of measurements made to determine the *effect of pressures up to 12,000 kg. per. cm.² and of temperatures from 0° to 275° C.* on the resistance of *lithium, sodium, potassium, gallium, bismuth, mercury, calcium, strontium, magnesium, titanium, zirconium, arsenic, tungsten, lanthanum, neodymium, carbon (amorphous and graphitic), silicon, and black phosphorus.* The data for W and Mg are improvements on data previously published; those for the other substances are new. The first six of these elements were studied in both the liquid and the solid states. The pressure coefficients of solid Ca, solid Sr, and both solid and liquid Li are positive; the coefficient of Bi is positive in the solid state, but negative in the liquid.

Modified Electron Theory of Metallic Conduction.—A previous theoretical discussion of measurements of the effect of pressure on resistance suggested most strongly that in metallic conduction the electrons pass through the substance of the atoms, and that the mechanism by which resistance is produced is *intimately connected with the amplitude of atomic vibration.* This view is here given quantitative form. The classical expression for conductivity, $\sigma = (e^2/2m)(nl/v)$, is retained; the number of free electrons is supposed to remain constant, their velocity is taken to be that of a gas particle of the same mass and temperature, and their mean free path is supposed to be many times the distance between atomic centres. The variations of path are then computed in terms of the variations of amplitude, and thus the variations of resistance are obtained and *compared with experimental results.* It is shown that the theory in this form explains Ohm's law, gives the correct temperature coefficient and the most important part of the pressure cofficient, avoids the difficulty of the classical theory with reference to specific heats, indicates a vanishing resistance at low temperatures, leaving open the possibility of super-conductivity, and retains the classical expression for the Wiedemann-Franz ratio. Besides these quantitative checks, the theory is shown to be entirely consistent qualitatively with all the new data; in fact, many of these new results, particularly the effect of pressure and temperature on the relative resistance of solid and liquid, seem to demand uniquely this conception of metallic conduction. AUTHOR.

1147. *Relation between Electrical Resistance and Tension in Bismuth.* **E. Zavattiero.** (Accad. Lincei, Atti, **29.** i. pp. 48–54, Jan. 18, 1920.)—The experimental arrangement and method of conducting observations is described and the results obtained are shown both in tabular and graphical form. It is found that during the process of traction the electrical resistance of the wire diminishes with increase of the load; for small loads proportionally to the deformation; with large loads less rapidly. Under the action of a constant tension in proximity to the limit of fracture, the specific resistance of the bismuth gradually increases. The action of a magnetic field is also considered. A. E. G.

1148. *Variation of Resistance of Nickel Steels due to Subsequent Heating.* **W. Del Regno.** (Accad. Lincei, Atti, **29.** ii. pp. 138–142, and 192–194, Aug.–Sept., 1920.)—Describes the results of experiments on a number of different samples of Ni steels including invar and platinite. It was found that in every case the resistance was changed, after heating, when the metal had returned to its original (room) temperature. The sign of the variation was dependent on the temperature to which the sample had been raised. Both with invar and platinite, as the temperature of the heating was increased, the resultant change of resistance changed sign at a point which appeared to correspond with the transformation point of the alloy. Successive re-heatings to the same temperature produced, in invar, slight changes, always in the same direction, but much smaller than that due to the first re-heating. The progressive changes of resistance which took place after a short interval subsequent to reheating were very gradual. J. W. T. W.

1149. *A New Property of Feeble Conductors of Electricity.* **G. Reboul.** (Comptes Rendus, **172.** pp. 210–212, Jan. 24, 1921.)—In a previous communication [Abs. 520 (1921)] the author has shown the conditions under which feebly conducting bodies traversed by a current act upon a photo-

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graphic plate ; in the present paper the cause of this phenomenon is sought. Two hypotheses naturally present themselves ; (a) The current produces an electrolysis of the water or salts contained in the sheets of paper or the conductors employed ; the gas liberated acts upon the photographic plate by simple contact with the silver salts of the sensitive layer ; (b) a brush or spark is produced, and these act upon the plate. It is shown that the action of the gas products is insufficient to explain the effects and that the ionisation produced in the surrounding gas is quite distinct from that which would be produced by a brush. It is suggested that the behaviour is just as if, at the points in which are the discontinuities of resistance, there were, either in the conductor itself or in the surrounding medium, falls of potential sufficient to produce a disruptive discharge. The discharges so produced would be accompanied by the emission of a very absorbable radiation, of which it is possible to determine the characteristics and which, while being invisible to the eye, may yet act upon the photographic plate in the same manner as ultra-violet or X-rays.

A. E. G.

1150. *Interpretation, by Dielectric Cohesion, of a Celebrated Experiment of J. J. Thomson.* **E. Bouty.** (Comptes Rendus, 172. pp. 731–733, March 21, 1921.)—In 1893 J. J. Thomson, exciting by induction the luminescence of a rarefied gas, was led to conclude from his experiment that the rarefied gas possessed a molecular conductivity of an electrolytic nature comparable with that of a solution of sulphuric acid of maximum conductivity. The author has shown, 1899, that at no degree of rarefaction does the gas possess the slightest trace of conductivity. A bulb containing rarefied air is placed between the plates of an air condenser and the intensity of the field progressively increased, starting from a certain *critical field*. The charge or discharge of the condenser now produces a sudden luminescence of the gas and an increase in the capacity is observed, showing that the gas has become a conductor. This conductivity did not pre-exist. It is the effect of an electromotive action sufficient to overcome the dielectric cohesion of the gas and to produce, at the expense of the molecules, gaseous ions of contrary signs. An explanation of Thomson's experiment is given and a method of simplifying that experiment described.

A. E. G.

1151. *Conductivity of Insulating Materials Near the Breakdown Voltage.* **J. E. Shrader.** (Phys. Rev. 17. pp. 502–507, April, 1921. Paper read before the Am. Phys. Soc.)—(a) In the *method of measurement* used, the recording instruments were protected from injury in case of puncture, by placing an insulated hot-kathode rectifier in series with the sample being tested. This enabled the current through the sample to be limited and also controlled by controlling the temperature of the kathode of the rectifier. When with a given applied voltage the current did not reach a constant max. value upon raising the temperature of the kathode, the voltage had reached the breakdown point. (b) *Three classes of insulating materials* were found whose conductivity, respectively, (1) obeys Ohm's law throughout ; (2) obeys Ohm's law up to near breakdown and then increases at an accelerated rate ; and (3) increases over the whole range of voltage at an accelerated rate to breakdown. In general, materials in Class 3 have the greatest dielectric strength ; those in Class 1, the least. Results are given only for three materials, namely, untreated cement paper, paraffined fish paper, and black treated cloth, which were selected as representative, respectively, of the three classes. AUTHOR.

1152. *Piezo-electric and Allied Phenomena in Rochelle Salt.* **J. Valasek.** (Phys. Rev. 17. pp. 475–481, April, 1921. Paper read before the Am. Phys. Soc.)—*Electric Hysteresis in Rochelle Salt.*—On the doublet theory of dielectric action, the dielectric displacement D, electric intensity E, and the polarisation P are analogous to B, H, and I in the case of magnetism. Rochelle salt shows an electric hysteresis in P analogous to the magnetic hysteresis in the case of iron. The loops obtained are displaced from the origin by an amount which gives a measure of the *permanent polarisation in the natural state.* The moment per unit volume in the natural state is of the order of 50 e.s.unit per/cm.^{2} under ordinary conditions, this being about $13 \cdot 3 \times 10^{-21}$ e.s. unit per cm.^{2} per molecule.

Piezo-electric Response of Rochelle Salt in an Electric Field.—Mechanical force and electric field are to a certain extent equivalent in producing a change in the piezo-electric moment. Measurements of the piezo-electric response in various applied fields therefore give curves of the same nature as the curves of dD/dE against E. Accordingly they show maxima displaced from the origin by the effect of permanent polarisation.

AUTHOR.

1153. *Relation between Photoelectric Effect and Contact Potential.* **P. Pringsheim.** (Deutsch. Phys. Gesell., Verh. 21. pp. 606–614, Sept. 30, 1919.)—Observations relating to Einstein's "$h\nu$" equation and Millikan's experimental results. A. B. W.

1154. *The Final Adjustment of Precision Inductances.* **G. E. Moore.** (El. Rev. 88. pp. 504–505, April 22, 1921.)—*General Considerations.*—The inductances referred to in this article are of the ironless type and of fixed value. Where approximate measurements only are sufficient, then adjustment may be made to one turn of the bobbin which serves as fixed support. With a high self-inductance—say, of one henry, which can be attained with about 2350 turns and a mean diam. of 15 cm.—it is possible to reach an accuracy of 0·1 % or even 0·02 % with one-turn adjustment; with low values (say of less than 100 millihenrys) adjustment to one turn is useless for precision work. This follows from the fact that self-inductance is proportional to (No. of turns)^2; [the reciprocal of (No. turns)^2] × value of the self-inductance roughly gives the one-turn value, which is relatively much greater for low than for high self-inductances. In the case of mutual inductances where on doubling the turns of one component winding the m.i. value is doubled, one turn represents a definitely important amount.

If consistent precision is required an open coil without any really solid support is not suitable; and a solidly confined coil being imperative, the most convenient form is the round bobbin with a square-cut slot. The best material for the bobbin is marble, but Cuba mahogany and similar hard woods thoroughly seasoned and impregnated are good substitutes. Preliminary adjustment may be made, an excess number of turns being left on, and final adjustment made after drying and polishing the wood.

1. *Self-Inductances.*—The following are the practical alternatives: (*a*) The position of the terminals is important. There are three simple

methods wherein these are disposed on the flat of one cheek: (1) a convenient method is that in which the last turn is finished exactly where the required precision value is reached, and the terminal is placed to suit; (2) the two may be located in the centre of the cheek. In both of these alternatives the short lengths of wire on the cheek should preferably be sunk into the latter; (3) the terminals may both be placed near the periphery of the cheek, in this plan as in (1) the arrangement is apt to cause trouble with the outside leads. The best method for arranging the terminal connections from the winding is to adjust finally in the winding slot itself. If one or more turns on the last layer are wound *with a greater diameter than that of the latter* the self-inductance can be reduced. This can be carried out by placing the adjusting turns on the inside of one cheek, or more conveniently by separating the turns from the last layer by a suitable number of windings of insulating strip, or by running a length of sleeving on the said turns of wire. (*b*) A crude, but effective, arrangement is to place the last layer on the outside of one cheek, connection being made to the terminals. This method is suitable for inductance bobbins enclosed in protective cases. (*c*) The previous device can be modified so as to sink the adjustment itself in the cheek (a circular pit can be cut at the centre of the bobbin, and one or more loops placed in this, the hole being afterwards filled in and covered). (*d*) If the self-inductance be adjusted to one turn *under* required value, the latter can be reached by connecting in series another inductance wound on a very much smaller bobbin, rough accuracy on this giving the required precision on the composite inductance. (*e*) In the case of solenoidal windings recourse may be had to the spacing-out of a certain number of turns. This is very effective with tiny inductances. One of a microhenry, for example, can be made up with four turns of (say) 30 S.W.G. wire on 3 cm. diam. tube, and the turns can be spaced out over a winding length of about 0·5 cm. With these small values the self-inductance of the internal terminal leads can sometimes be utilised.

II. *Mutual Inductances.*—In fixed types the two windings may be applied concentrically in a single winding slot of one bobbin, which in general is the best method. For precision adjustment the number of turns on *one* winding only (the most accessible) may be altered, and any of the methods (*a*), (*b*), (*c*), (*d*), and (*e*) above may be utilised. The method of final adjustment used in Campbell's variable mutual inductance is briefly described in the article, and in conclusion the author notices certain *precautions* which are necessary in actual measurement; otherwise accurate adjustment will be rendered useless. External leads must be considered in case their inductance and capacity may militate against test accuracy. Generally the leads can be "shorted" while the test zero is determined, and as little change as possible should be made in the disposition of the leads relative to the inductance. When using alternating current for test purposes fair constancy of frequency is essential. Stray fields and the mutual effect between the test apparatus and the inductance must be counteracted. Lengthy leads are inadvisable. The mean of readings taken with the inductance turned through 180° should be accepted, and care must be taken to readjust the separate sections of large subdivided self-inductances, the others remaining in series, after the first separate winding and adjustment. An inductance can possess a temperature coefficient, and large temperature changes are to be avoided.

J. J. S.

ALTERNATING CURRENTS AND MAGNETISM.

1155. *Magnetic-Mechanical Analysis of Cast Iron.* **S. R. Williams.** (Am. Soc. Testing Materials, Proc. 19. Part 2. pp. 1–6, 1919.)—Describes experiments carried out to check results by Rood [see Abs. 332 (1917)] on the relation between tension and magnetic permeability; Rood found that cast iron does not have its permeability affected by tension. The present author shows by a direct and also an indirect method that cast-iron rods, whose composition is given, have their permeabilities changed by tension. The direct method shows increases in induction for various tensile loads and the indirect method, consisting of measurement of length with varying magnetic fields, shows increases with the strength of the field. It is suggested that Rood's specimens require further examination. C. O. B.

1156. *Eddy Currents with Sudden Change of Magnetisation.* **B. Wwedensky.** (Ann. d. Physik, 44. 7. pp. 609–620, April 19, 1921.)—A theory of eddy currents is developed for the case of a circular iron cylinder in which the magnetisation changes when the applied field is suddenly reduced from a constant value to zero. The only field then active is that due to the eddy currents, and the equations for field and eddy-current density form the starting point, and a series is obtained which gives the distribution of magnetic induction within the cylinder. The demagnetisation begins at the surface and spreads gradually into the interior, the time taken depending on the thickness, permeability, and conductivity of the iron. As regards the distribution of the eddy currents, these are initially condensed at the surface, but gradually penetrate into the interior so that the current density is not always a maximum at the surface. The magnetic flux ϕ in the cylinder is next expressed in the form of a series in terms of a function $\xi = t/4\pi\mu\sigma r^2$, where t represents time, μ permeability, σ conductivity, and r radius of cylinder; ϕ and ξ are graphed, and the shape of the graph is verified by means of the experimental work of Klemenčič, Gildemeister, and Wwedensky. G. E. A.

1157. *Anomaly of Expansion during Magnetic Transformation.* **P. Chevenard.** (Comptes Rendus, 172. pp. 320–322, Feb. 7, 1921.)—The anomaly of expansion observed in ferro-nickels, α-iron, nickel, cementite, and other substances is sought for in pyrrhotine and magnetite. The expansion of pyrrhotine is abrupt in the neighbourhood of 320°; during cooling, the length-temperature curve at first almost retraces itself, but gradually deviates from the heating curve, and the specimen when cold is longer by several thousandths than at first. On repeating, the temperature of rapid expansion is as before, but the actual increase is less, the oftener the heating is repeated. It is considered that an allotropic change takes place with a change of phase, analogous to the $\alpha \rightleftharpoons \gamma$ change in iron. In magnetite, after a preliminary heating, the coefficient of expansion, 8×10^{-6} at 0°, increases to a maximum of 24×10^{-6} at 570°, then diminishes rapidly. The transformation is almost rigorously reversible, and is without change of phase. G. E. A.

1158. *Mutual Action of Magnets and Currents Immersed in a Magnetic Liquid.* **H. Chipart.** (Comptes Rendus, 172. pp. 589–591, March 7, and pp. 750–753, March 21, 1921.)—The case, considered from the mathematical standpoint, is that of homogeneous and isotropic solids capable of permanent and induced magnetisation and of being traversed by permanent currents. If the induced magnetism is in accordance with Poisson's law, a rule may be stated as follows: To calculate the mutual actions of magnets and currents immersed in an infinite liquid of constant permeability μ, proceed as if the bodies were in a vacuum and possessed permanent magnetisations and permeabilities $1/\mu$ times their actual values; the final result is to be multiplied by μ. In the second paper, some particular conclusions, obtained by applying the above rule, are stated. The mutual actions of linear currents are proportional to the permeability μ of the liquid; a similar statement holds for magnetic shells. In the case of two magnetic needles, the effect is inversely proportional to μ, whilst with a shell and a needle the effect is independent of μ. **G. E. A.**

1159. *Magnetic Susceptibility of Natural and Artificial Oxides (Ferric Oxide, etc.).* **E. F. Herroun** and **E. Wilson.** (Phys. Soc., Proc. 33. pp. 196–205; Disc., 205–206, April, 1921.)—(1) The susceptibility of ferric oxide, as occurring in nature, varies through a wide range, but in the case of artificial preparations the range of variation may be much greater. (2) The highest susceptibility exhibited by artificial ferric oxide occurs when either ferrous or magnetic oxide is oxidised at a high temperature in the anhydrous condition. From hydrated magnetic oxide the susceptibility, though considerable, is much less. (3) The lowest susceptibility is obtained from native hæmatites, or naturally oxidised chalybite, or by the ignition or precipitation of ferric salts. (4) It appears that the passage through the stage of magnetic oxide impresses more pronounced magnetic properties upon the resulting ferric oxide. (5) The actual values of susceptibility have been obtained in the case of ferrites, one of the most conspicuous being that of copper. (6) Heating feebly magnetic ferric oxide with a basic oxide, *e.g.*, lime or magnesia, increases susceptibility (confirming List and others). (7) When higher susceptibility has been produced by heating ferric oxide with a basic oxide such as that of silver or mercury, subsequent removal of the metal leaves the ferric oxide in a magnetic condition. (8) The chemical compounds (aluminates) formed when ferric oxide is replaced by aluminic oxide show no definite increase in susceptibility, which is in marked contrast with the ferrites. [See Abs. 1558 (1919).] **AUTHORS.**

1160. *Reversible Magnetic Permeability.* **R. Gans.** (Ann. d. Physik, 64. 7. pp. 621–624, April 19, 1921.)—The results obtained by Erhardt [Abs. 706 (1918)] do not agree with those obtained by the author [Abs. 546 (1911)]. The present paper gives results obtained by an improved method for mild steel and for hardened Remy steel which confirm the author's previous work. **A. W.**

1161. *Demonstration of Ampère's Molecular Currents.* **E. Beck.** (Ann. d. Physik, 60. 2. pp. 109–148, Oct. 7, 1919.)—The molecular magnet, viewed as a gyrostat, has angular momentum $2Mm/e$, or λM, where m is the mass and e the charge of the rotating electron, and M the magnetic moment of the molecule. Any change in the direction of magnetisation of such a body is accompanied by an impulsive couple due to the change of direction of the axis of rotation. Einstein and de Haas [Abs. 1123 (1915)] suspended a thin iron rod axially in a vertical coil which supplied a strong field. On the above supposition, reversal of the field should be accompanied by rotation of the rod. Employing an alternating current of the same frequency as the torsional vibrations of the rod, Einstein and de Haas determined the value of λ which is taken as the measure of this (Einstein) effect and is deduced from the resonance curve of the rod's oscillations by means of the equation:

$$\lambda = (\pi^2 Q a_m \nu / I)[b/(1 - 6^2)]^{1/2},$$

where Q is the moment of inertia of the rod; a_m the amplitude of its vibrations for maximum resonance; I the magnetisation of the rod in the maximum field; ν the difference between the field frequency and the frequency for maximum resonance; and b the amplitude ratio a/a_m. The method promising an accurate determination of e/m, the author repeated and extended Einstein and de Haas measurements with various improvements. A new frequency meter was constructed to measure small changes in frequency. The alternating magnetic field caused torsional vibrations of a stretched wire which was then adjusted for resonance, and the change of frequency was found from the change of length which was measured by means of a micrometer screw. Three vibrating rods were tested, two of iron and one of nickel, all 20 cm. long; the second iron vibrator consisted of a bundle of seven soft-iron wires. The measurement of λ is exemplified for all the specimens, and resonance curves are given; the value found for λ, viz., $0{\cdot}60 \times 10^{-7}$ for iron and $0{\cdot}64 \times 10^{-7}$ for nickel, is somewhat more than half the value expected from the accepted value for e/m, namely, $1{\cdot}765 \times 10^7$ e.m. units. The oscillations of the current and of the rods were recorded photographically; theoretical considerations showed that if negative rotating charges were concerned, the two curves would be parallel; the photographs verified this. G. E. A.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1162. *The Orientation of Molecules in Surfaces.* VI. *Cohesion, Adhesion, Tensile Strength, Tensile Energy, Negative Surface Energy, Interfacial Tension, and Molecular Attraction.* **W. D. Harkins** and **Y. C. Cheng.** (Am. Chem. Soc., J. 43. pp. 35–53, Jan., 1921.)—This paper presents the first accurate data, and almost the first of any kind, from which the total interfacial energy may be calculated, and discusses the work of adhesion and of surface cohesion, the interfacial tension and free surface energy, the tensile work, the energy of adhesion, of cohesion, and of surface cohesion, the tensile energy, the internal pressure (or cohesion), and the related molecular attraction. These relations are illustrated by extensive experimental values obtained for 12 organic liquids as related to water. These data indicate two new and important relations. First, that certain surfaces or interfaces between two liquids exhibit a negative surface energy, or, in other words, energy is given off when the surface is formed. This is just the opposite of what has been found before: for all surfaces previously known, with the exception of the case when crystalline liquids are undergoing transformation,—a somewhat extraordinary case,—have required the expenditure of energy for their formation. Second, while ordinary surfaces cool off when they are expanded, these surfaces and some others which have been found in this investigation, rise in temperature when they are formed. The liquids, at whose phase boundary with water a negative surface energy is exhibited, are: heptin (with a triple bond at the end of the chain), normal and secondary octyl alcohol, and heptaldehyde. All of the above liquids and a higher paraffin have a negative latent heat of the phase boundary, which indicates that the interface rises in temperature when it is expanded. The addition of one oxygen atom to the 26 other atoms present in octane to give octyl alcohol increases the tensile energy by only 2 %, while it increases the adhesional energy by 65 %, and similar relations are found for the organic acids, aldehydes, and heptin. In contrast with this, it is found that the double bonds increase the tensile energy greatly, about 40 % in the change from hexane to benzene, while the adhesional energy towards water is increased by only about 3 %. It is found, too, that the very symmetrical halogen derivatives, carbon tetrachloride and ethylene dibromide, which give specially high values for their own tensile energy, give specially low values for their adhesional energy toward water. The tensile energy of ethylene dibromide, on account of its symmetry, is higher than that of ethylidene bromide. These facts are easily explained on the basis of the hypothesis that the unsymmetrical molecules are orientated in the surface, and therefore give very strong evidence in favour of the orientation hypothesis. When a bar of heptin (or of an organic acid, alcohol, aldehyde, amine, etc.) is pulled apart, the break occurs where the electromagnetic field (largely electrical) and the resulting attraction is weakest, that is between the hydrocarbon chains, and in order that this may be the case the hydrocarbon chains turn into the nascent surface in the process of its formation. In benzene the symmetry of the molecules is so great that the break must occur between certain of the unsaturated groups, *i.e.*, where the intermolecular electromagnetic field is high. The fact that the adhesional energy of octane is so greatly increased by the addition of one oxygen atom to form octyl alcohol, indicates by similar reasoning that the oxygen atoms turn toward the water at their interface. Thus the adhesional energy toward water is determined by the strongest electromagnetic fields in the molecule, while the tensile energy is determined by the weakest fields, provided the molecules are unsymmetrical. The solubilities of heptylic acid, heptin, and heptaldehyde have been determined, and are found to be nearly the same, which indicates that the length of the hydrocarbon chain is of more importance in determining the solubility than the nature of the active group at the end of the molecule, provided that the activity of the latter is not too widely varied. For the first time the surface energy relations of a paraffin with a triple bond at the end of the molecule have been worked out. The triple bond is found to increase the adhesional work from about 42 to 67, and the total adhesional energy from 105 to 147, the lower values given being those of the corresponding saturated compounds. The introduction of one oxygen atom increases the adhesional work to 90 and the energy to 164. This indicates that the triple bond has a greater relative effect on the adhesional energy than on the adhesional work at 20°, as compared with an hydroxyl oxygen atom. The relations worked out in this paper should be of fundamental importance in connection with the study of lubrication, flotation, and all other adhesional phenomena. Similar data for the adhesional relations between mercury and organic liquids have been worked out. H. H. Ho.

1163. *Oxidation and Luminescence of Phosphorus.* I. **H. B. Weiser** and **A. Garrison.** (J. Phys. Chem. 25. pp. 61–81, Jan., 1921.)—The authors' experiments show that, when the vapour only of phosphorus is brought into contact with oxygen, the oxidation proceeds at a velocity proportional to the concentrations of the reacting substances. It is usually assumed that the concentration of phosphorus vapour is constant in contact with solid phosphorus and hence that the velocity of oxidation is proportional to the concentration of the oxygen, but this is not the case at temperatures below 25° or for partial pressures of oxygen exceeding a certain value—the boundary pressure—owing to the formation of a film of oxide on the surface of the phosphorus. The formation of such film depends on the velocity with which the oxygen is supplied, on its rate of diffusion, and on the rate at which the phosphorus evaporates and its vapour diffuses. The boundary pressure represents the partial pressure of oxygen above which a protecting film of oxide prevents the vaporisation and oxidation of phosphorus; it is not constant since any factor which either diminishes the concentration or rate of diffusion of oxygen or increases the pressure or rate of diffusion of phosphorus vapour will increase the boundary pressure, and vice versa.

The intermittent luminescence observed by Centnerszwer in the narrow critical region between the so-called boundary pressure and glow pressure is probably due to the periodic rupture and re-formation of the protecting oxide film. T. H. P.

1164. *Crystal Structures of the Ammonium Halides Above and Below the Transition Temperatures.* **G. Bartlett** and **I. Langmuir.** (Am. Chem. Soc., J. 43. pp. 84–91, Jan., 1921.)—Ammonium chloride, bromide, and iodide exhibit polymorphism and have well-defined transition temperatures. Application of X-ray crystal analysis by Hull's method [Abs. 380 (1918)] shows that the high-temperature form of each of these salts has a simple cubic structure like sodium chloride, each ion being surrounded by six equidistant ions of the opposite polarity. The ordinary or low-temperature forms of the chloride and bromide show a centred cubic structure, each ion being surrounded by eight equidistant ions of the opposite polarity, arranged like the angles of a cube about its centre. These results furnish confirmatory evidence that the ammonium ion has tetrahedral symmetry, whilst the alkali metal and halogen ions are of cubic shape. Low temperatures, high pressures, and anions of low atomic volume cause the shape of the ammonium ion to be a factor of predominating importance in determining the crystal structure. High temperatures, low pressures, and anions of large volume make the shape of the ammonium ion of relatively less importance, so that under these conditions ammonium salts tend to become isomorphous with corresponding potassium salts.

The numerical data relating to the crystal structures of the ammonium halides are given in the following table.

Salt.	Temp.	Arrangement of Ions.	Distance between Like Ions	Distance between Unlike Ions	Density (Calculated).	Molecular Volume.
			(in Ångstrom Units).			
NH_4Cl	20°	Centred cubic	3·859	3·342	1·536	34·9
NH_4Cl	250	Simple cubic	4·620	3·266	1·265	42·3
NH_4Br	20	Centred cubic	3·988	3·453	2·548	38·4
NH_4Br	250	Simple cubic	4·88	3·45	1·972	49·7
NH_4I	20	Simple cubic	5·090	3·60	2·563	56·6

T. H. P.

1165. *Stainless Steel.* **J. H. G. Monypenny.** (Chem. News, 121. pp. 318–320, Dec. 31, 1920.)—Stainless steel contains 11–14 % Cr, and generally not more than 0·45 % C. The little Ni often present is no advantage and may cause trouble in heat treatment. With 12 % Cr the eutectoid point occurs at 0·3 % C and it is only this amount of carbon which goes into solution at the Ac1 point 800–830°. The remainder dissolves progressively over a range of 200 deg. C. The sulphide present in Cr steels is decomposed to only a small extent in acids and appears to be in solid solution. On slow cooling the Ar1 point is about 750° C., but the steel possesses marked air-hardening properties, giving a Brinell number of 500 when freely cooled from 900° C. As a result the steel must, after rolling, be slowly cooled in the range 800–600° C. to prevent hardening and cracking. High-carbon stainless steel cooled from high temperatures is austenitic and soft, but is unmachinable. The tempering colours form on stainless steel at distinctly higher temperatures than on plain carbon steels, *e.g.*, straw at 300° C. and light blue at 600° C. Stainless steel has the max. resistance to corrosion in the hardened condition which is not diminished by tempering up to 500° C., but even with soft condition it is only slowly attacked. H_2SO_4 and HCl attack the steel readily. This steel does not scale to any extent when heated to 800–850° C. It is most suitable for engineering purposes when oil- or air-hardened from 900° C. and tempered from 650–750° C., when the general tensile properties are :

Yield Point. Tons per sq. in.	Max. Stress. Tons per sq. in.	Elongation. %.	Reduction of Area. %.	Izod (Impact). Ft.-lbs.
30–55	45–65	15–28	35–65	25–70

The material is suitable for aeroplane valves, since in addition, it retains its strength well at high temperatures, *e.g.*:

Temperature, °C.	600	700	800	850
Tensile strength tons, per per sq. in.	24·2	12·1	6·6	6·6

It is with the higher carbon contents that the strength is best retained.

F. C. T.

1166. *Metallographic Examination of Glossy Electrolytic Copper.* **G. Grube** and **V. Reuss.** (Zeits. Elektrochem. 27. pp. 45–52, and 53–54, Jan. 1, 1921.)—The "Glanzkupfer" of the authors is the glossy deposit obtained when gelatin (0·6 gm. per litre) is added to the copper sulphate bath. Taking sections at right angles to the surface of the deposit and etching these with nitric acid for photomicrography, they found the metal arranged in alternate layers of copper and gelatin; in polishing the sections parallel to the surface the gelatin is removed and overlooked. The deposition, it is concluded, takes place in two stages: in the first an elastic film of the disperse system copper-gelatin is deposited; during the second stage the deposit separates into layers of crystallising copper and gelatin. The kathode potential gives a curve showing peaks at intervals of a few minutes, marking the fixation of the gelatinous copper film which is pressed against the kathode by electro-osmosis. The second paper refers to the somewhat similar studies of Sieverts and Wippelmann [see Abs. 497 (1916)] of which the authors had not been aware; Grube does not accept their explanation. H. B.

1167. *Dilatation of Fe-Ni and Fe-Ni-Cr Alloys.* **P. Chevenard.** (Comptes Rendus, 172. pp. 594–596, March 7, 1921.)—The dilatation curve of any ferromagnetic substance is made up of two parts corresponding to the dilatation of the higher and lower allotropes. If the dilatation curve of the high-temperature allotrope be extrapolated to low temperatures, a difference curve between this and that of the lower temperature allotrope can be plotted. The value of this curve at absolute zero (obtained by extrapolation) is plotted against composition for pure Fe-Ni alloys, and for similar alloys containing 5 %, 10 %, and 15 % of Cr. All such curves show a sharp cusp at a temperature corresponding to the composition of the compound Fe_2Ni, though with the addition of Cr the cusp becomes less and less pronounced. The curve for the pure Fe-Ni alloys cuts the zero dilatation ordinate at about 58 %, 80 %, and 90 % of Ni. J. L. H.

1168. *Reversible Action of Carbon Monoxide on Iron Oxides.* **G. Chaudron.** (Comptes Rendus, 172. pp. 152–155, Jan. 17, 1921.)—The author places a weighed mass of ferric oxide in a tube, heated in an electric furnace, admits known volumes of CO, and determines the gases when equilibrium is obtained in successive experiments. Below 580° there is only the reaction $Fe_3O_4 + 4CO \rightleftharpoons 4CO_2 + 3Fe$; above 580° iron is reduced by two reactions: $F_3O_4 + CO \rightleftharpoons 3FeO + CO_2$, and $FeO + CO \rightleftharpoons Fe + CO_2$. An equilibrium diagram, percentage of CO_2 plotted as ordinate against temperature, is given; on this diagram the S-shaped curve of the dissociation of CO (producing a deposit of carbon at lower temperatures) is also marked. There is further the reaction

$4FeO \rightleftarrows Fe_3O_4 + Fe$. That this reaction takes place was shown by fusing a bar of steel in the oxy-hydrogen flame, and heating the FeO formed for 7 days in a sealed tube to 500°; the mass then contained some metallic iron, but that iron disappeared after further heating to 800° for 4 hours. H. B.

1169. *Effect of Depth of Copper-plating on Carburisation.* **F. P. Zimmerli.** (Am. Soc. Mech. Eng., J. 42. pp. 565–566 and 602, Oct., 1920.)—A mild steel was copper-plated in a bath of 20 gm. each of the following per litre: Na_2SO_4, $Na_2CO_3 . 10H_2O$, $NaHSO_3$, $Cu(C_2H_3O_2)_2 . H_2O$ and KCN with a current density of 0·003 amp./cm.² at 20° C. It was then carburised at 1700° F. for periods up to 12 hours. It was found that a copper deposit 0·0002 mm. thick was sufficient to prevent carburisation. F. C. T.

1170. *Crystal Growth and Recrystallisation in Metals.* **H. C. H. Carpenter** and **[Miss] C. F. Elam.** (Inst. of Metals, J. 24. pp. 83–131; Disc., 132–154, 1920. Engineering, 110. pp. 385–389, Sept. 17; 424–426, Sept. 24, and pp. 486–490, Oct. 8, 1920.—Abstract.)—Gives details of a large amount of experimental work carried out on the structural changes which occur during the softening of worked metals. The two aspects of the changes here dealt with, which occur as a result of annealing worked metals are crystal growth and recrystallisation. By "crystal growth" is meant the rearrangement of certain crystals in an aggregate to conform with certain other crystals, during which process the latter increase in size by the addition of re-oriented material at the same time as the former decrease in size by the same amount. By "recrystallisation" is meant the re-orientation of a crystal or group of crystals. The new arrangement starts from new centres and is quite independent of the old system of orientation and always gives a refined structure. Changes in crystal size may result on heating a metal after it has been plastically deformed, on heating or cooling a metal through a phase change, or on heating metals which have been electrically deposited. The paper deals only with the effect of heating plastically-deformed metals and for the experimental work, samples of Al and of an alloy of tin and antimony containing 1·5 % of Sb were employed. The alloy was used in the form of a casting. In this condition it is complex in structure and very much cored, but on prolonged annealing, the Sb passes into solution and a single-phase alloy results. If a piece of this alloy be polished, etched, and heated to 150–200° and growth of any of the crystals takes place, the position of the new boundary is marked by a new line. The alloy, after etching with ammonium sulphide, tarnishes on heating; there is always a colour contrast between adjacent crystals and the colour fixes the original boundaries. If new boundaries appear inside this colour boundary, it shows that the adjacent crystal is growing into it; if outside, then it follows that the crystal is growing into its neighbour. The boundary markings are only formed when the specimen is cooled, and a number of such lines may be obtained by repeatedly heating and cooling the specimen. The results of the observations made show that not only do large crystals invade small ones, but the reverse often takes place, especially in the early stages of growth following recrystallisation, and a crystal may grow and be invaded at the same time. The conclusions arrived at are that growth does not depend upon the relative size of the crystals; the relative orientation of the crystals does not appear to affect growth; a crystal which is being invaded by one crystal, may grow at the same time, at the expense of another crystal; the rate of growth is not constant for any given time at any particular temperature; the change of orientation is accompanied by a difference of level of the surface, which is the boundary marking observed. The difficulties of determining whether the crystals of castings grow as a result of heating are pointed out and the results of experiments are given which confirm previous observations that no growth takes place on annealing, without previous deformation. The results of experiments described, show that the effects of work followed by annealing can be divided into three categories, according to the degree of deformation: (1) Slip bands or twins or both may be produced, giving a certain permanent deformation, but on annealing they are reabsorbed, without further change. The effect of the deformation is only permanent in so far as the metal has undergone a slight change in shape; (2) growth of some of the existing crystals may take place. For this a further amount of deformation than for (1) is required; (3) recrystallisation may occur. This is always followed by crystal growth if sufficient time be given. All deformation beyond a certain fixed amount gives this result. The amount of deformation required to produce the above results, varies with the subsequent annealing temperature.

It is pointed out that the only theory of recrystallisation previously put forward is that enunciated by Mathewson and Phillips and supported by Howe and Jeffries. This theory assumes that inner surfaces are formed in the crystal in the process of slip due to work and that work destroys the uniformity of orientation of a crystal. In connection with this theory it is necessary to take into consideration the fact that there is no evidence that recrystallisation takes place by a process of disintegration of the crystal, but rather that recrystallisation begins from a few centres on the old crystal boundaries. There is also no evidence in support of the assumption that the orientation of a crystal is altered by work, and lastly Matthewson and Phillips themselves admit that recrystallisation is frequently brought about on annealing, although no inner surfaces, *i.e.*, "etch-bands," had been visible beforehand. The results of experiments on the annealing of cold-worked Al show that large crystals are not formed rapidly, but only after annealing for three days at a high temperature (550°). They are not formed at all at 500° and are not so large when annealed at 645° as at 550°. Different results were obtained with samples of different purity. The purest samples gave the largest crystals, while ordinary commercial Al frequently gave none. The limit of growth was reached in a fixed time beyond which no further change could be detected, and the large crystals formed appeared to be in equilibrium with the small ones when the final condition was reached.

Although no theory is put forward to explain all the phenomena observed, the theories of crystal growth which have already been put forward are referred to, namely: (1) The theory of Ewing and Rosenhain which depends on the assumption that there is always sufficient impurity present to form an intercrystalline eutectic; (2) the theory of Rosenhain and Jeffries based on the "amorphous cement" theory; both these theories are shown to fail to account for the observations made unless it can be shown that the crystals of castings will grow or that there is some fundamental difference between the boundaries of castings and those of worked and annealed metals. The authors consider, however, that energy is imparted to the metal during deformation, but this energy cannot be stored in amorphous vitreous films which, according to Beilby, are the cause of work-hardening in metals, because the growth of crystals in worked metal proceeds after all mechanical hardening has been removed. Neither can the energy be stored in the amorphous cement round the crystals, as conceived by Rosenhain, because all the available evidence is against the view that the crystals of castings grow and because the greater the surface area of a crystal, the more energy it should possess, and on this view a large crystal should absorb a small one, whereas it has been shown that this is by no means always the case. C. O. B.

1171. *Effect of Antimony and Arsenic upon Admiralty Gun-Metal.* **R. T. Rolfe.** (Inst. of Metals, J. **24**. pp. 233–264; Disc., 265–283, 1920. Engineering, 110. pp. 689–691, Nov. 19, and pp. 752–754, Dec. 3, 1920.—Abstract.)—Gives the results of work carried out in order to establish the exact effect of the different impurities found in commercial gun-metal.

Effect of Antimony.—In sand-cast gun-metal, the effect of a progressive increase in the proportion of Sb is in the direction of hardening and embrittling it, accompanied by a loss in strength and ductility. With 1 % Sb the ultimate stress figure approximates to, whilst the elongation figure falls just below, the minimum laid down by the Admiralty specification. Therefore, the max. permissible amount of this impurity appears to be about 0·75 %. There is no apparent effect on the soundness of sand-cast gun-metal containing up to 1·5 % Sb, and no differences in microstructure are observable. In chill-cast gun-metal, melted once, the same effects as regards ultimate strength are seen, but modified by the chilling. In metal which has been melted twice, chill castings containing increasing proportions of Sb are increasingly unsound, first showing this tendency to an abnormal degree with the alloy containing 1 % Sb. *Effect of Arsenic.*—In sand-cast gun-metal, melted once, the effect of a progressive increase is to cause a progressive falling off in the strength and ductility. For the maintenance of a safe margin over the specification minimum figures, a maximum of 0·3 % should not be exceeded. There is no apparent effect on the soundness of proportions of As up to 1 %. In metal which has been melted twice, however, As appears to cause unsoundness in chill castings, and although metal with 0·4 % gives sound castings, with metal containing 1 %, the castings were unsound. C. O. B.

1172. *Behaviour of Beta Brass when Cold-Rolled.* **F. Johnson.** (Inst. of Metals, J. **24**. pp. 301–311, 1920. Engineering, 110. pp. [illegible], Dec. 31, 1920.)—Gives detailed results of the examination of a sample of cold-rolled beta brass, made from electrolytic copper and zinc and containing 55·6 % Cu. After annealing the cast ingot for one hour at 650° C., it was cold rolled by a number of passes to a 50 % reduction. This resulted in a marked increase in tenacity and hardness and a decrease in elongation. There was no alpha phase present, and it was remarkable that a beta brass was amenable to such severe deformation. On carefully polishing and etching specimens, a confused maze of straight dark lines was revealed. These lines were found in series, in each of which they were parallel to one another, the series crossing each other at various angles. After re-polishing and again etching, the lines reappeared. As a result of the examination it is concluded that these conspicuous de-

formation bands belong to the same category as the Neumann lamellæ found in meteorites and in ferrite which has been subjected to shock.
C. O. B.

1173. *Influence of Gases on High-grade Brass.* **T. G. Bamford** and **W. E. Ballard.** (Inst. of Metals, J. 24. pp. 155–186; Disc., 187–200, 1920. Engineering, 110. pp. 390–394, Sept. 17, 1920.—Abstract.)—Describes experimental work carried out with a view of ascertaining the influence of gases on high-grade brass and shows that CO_2 behaves almost as a neutral gas; that a small regular absorption takes place in the case of carbon monoxide, and a fairly large regular absorption in the case of hydrogen; and that with SO_2, rapid absorption commences at 300° and continues up to 1020°, at which temperature absorption ceases and an evolution of gas commences which becomes more rapid up to 1100°. The scale formed on heating brass in an atmosphere of SO_2 contains sulphides and oxides of the metals.

A large amount of work was done on the influence of hydrogen and the following conclusions were arrived at:—

(1) Hydrogen dissolves in 70 : 30 brass in very large quantities between 500° and 900°. (2) The quantity absorbed is not a mere function of temperature and pressure, but is affected by the character and dimensions of the surface. (3) The major portion of the hydrogen absorbed is usually retained on cooling. (4) Large quantities of the hydrogen retained may be removed by treatment with a neutral gas at 600° or above. An investigation of the relationship between the casting temperature and the quality of brass castings indicates that in ordinary foundry practice, using a coke-fired natural draught wind furnace, it is impossible to impair seriously the mechanical properties of the casting by overheating. Cooling the metal to within 40 deg. of the liquidus, will, however, ruin the properties and probably render the castings porous. In the casting of tubes a higher temperature is required than is the case with solid ingots and should not be below 1150°. Exceptionally prolonged heating of the metal results in the loss of zinc but does not impair the properties of the castings. The furnace treatment is not a deciding factor in influencing the quality of the casting, but the pouring temperature is the important factor. When unsoundness is found in brass castings, it is usually confined to the upper portions.
C. O. B.

1174. *Constitution of the Nickel-Iron Alloys.* **D. Hanson** and **H[ilda] E. Hanson.** (Iron and Steel Inst., J. 102. pp. 39–60; Disc., 61–64, 1920. Engineering, 110. pp. 620–623, Nov. 5, and pp. 655–657, Nov. 12, 1920.)—When obtained by prolonged soaking in equilibrium, these alloys containing about 0·05 % C, 0·1 % S, and 0·08 % P consist of a eutectoid series. The limits of the eutectoid horizontal are at 9 and 33 % Ni; the eutectoid corresponds to about 25 % Ni and occurs about 350° C. A maximum occurs around 70 % Ni, dropping to 370° C. for pure Ni and to the eutectoid line at which the alloys become non-magnetic. F. C. T.

1175. *Manufacture of Cu-Al Alloy with 8 % Copper.* **R. J. Anderson.** (Chem. and Met. Eng. 23. pp. 883–887, Nov. 3, 1920.)—This material, known as "No. 12. Alloy," is best made by charging together ingots of aluminium, of "No. 12" scrap and a copper-rich alloy 50 Cu : 50 Al in the required proportions. In small melts (25 lbs.) light copper sheet or punchings may be substituted for the 50 : 50 alloy, which are added to the molten Al. F. C. T.

1176. *New Deoxidisers for Steel.* **J. R. Cain.** (Chem. and Met. Eng. 23. pp. 879–882, Nov. 3, 1920.)—An account of work done on the fusibility of the oxidation products obtained from alloys of Mn : Si, Mn : Ti, Mn : Si : Al, Mn : Si : Ti, and Mn : Al : Ti. Of these the next fusible, and hence possibly the best, are the following :—

Composition, %.				Melting-point of Mixed Oxides.
Mn.	Si.	Ti.	Al.	
75	24	—	—	1228° C.
41	—	59	—	1160
49	33	18	—	1130
52	35	—	13	1121
47	—	41	12	1320

F. C. T.

1177. *Metallographic Methods of Investigation of the Non-metallic Inclusions in Iron and Steel.* **M. Matwieff.** (Rev. de Mét. 17. pp. 736–752, Nov., 1920.)—FeO, unlike Mn_3O_4, is reduced by hydrogen at a red heat. A 0·2 % aqueous solution of oxalic acid attacks sulphur inclusions in 20–30 secs. The microstructures of a series of melts of oxides, sulphides, and silicates are considered. F. C. T.

1178. *Influence of Iron on the Mechanical Properties of Cast Aluminium.* **L. Guillet** and **A. Portevin.** (Rev. de Mét. 17. pp. 753–756, Nov., 1920.)—The presence of iron in chill-cast Al increases the hardness and shear strength and reduces the ductility. With 4 % Fe the alloy is very brittle. The addition of iron appears to have no advantageous effect in the cast state.

Fe, per cent.	Brinell No., 500 kg.	Impact.		Max. Stress in Shear, kg.
		Energy Absorbed, m.-kg.	Angle of Bend.	
0·7	22	9·5 (unbroken)	135	34
1·7	28	5	44	45
3·0	34	3	40	50
3·9	37	3	30	50

F. C. T.

1179. *Notes on the Effect of Nitrogen in Steel.* **O. A. Knight** and **H. B. Northrup.** (Chem. and Met. Eng. 23. pp. 1107–1111, Dec. 8, 1920.)—An investigation carried out to determine the effect of ammonia at high temperatures on steel and its relation to the erosion of guns, etc. The effect on the tensile properties of a steel containing 0·81% C, 0·17%

Si, 0·56 % Mn and S and P each less than 0·04 %, is indicated in the following table :—

Treatment.	Tensile Strength, lbs. per sq. in.	Elongation, % on 2 in.	Reduction in Area, %.
Annealed	98,500	13·6	22·1
Heated in NH_3 for 8 hrs. at 650° C.......	79,500	2·0	0·0
Do. and then in H for 8 hrs. at 650° C. ..	89,000	4·5	6·6

The hydrogen treatment removed the white superficial layer produced by the ammonia. Pure tungsten is, unlike all other pure metals, not effected micrographically by the ammonia treatment. High-carbon steel is much more resistant than low-carbon steel. White cast-iron and monel metal are but slightly attacked, "Stellite" and "Nichrome" still less, while Cr-V steel is the best resister of all. The effect of the carbon content of steel was investigated on a case-hardened bar. In the high-carbon region there was a very hard and brittle case which etches dark on its outer $\frac{3}{5}$ with 4 % HNO_3 in alcohol (and also with Stead's reagent) and light on its inner $\frac{2}{5}$. In this latter area a columnar structure perpendicular to the surface was developed with deep etching. Below this case no change of structure was observed. In the low-carbon regions the case was as before ; beneath it was a thin layer of pearlite, then one of unchanged ferrite, after which was a thick zone of ferrite containing the "nitrogen needles." These latter are not darkened by Stead's reagent. The case, so long as it is unbroken, is very resistant to accelerated corrosion tests ; if broken, however, corrosion is rapid. It is believed that the formation of such a brittle nitrogen case plays an important part in the erosion of gun-tubes. F. C. T.

1180. *The Lewis Theory of Velocity of Chemical Reaction.* **F. A. Lindemann.** (Phil. Mag. 40. pp. 671–673, Nov., 1920.)—The author briefly recapitulates the argument by which W. C. McC. Lewis supported the theory he put forward about a year ago [Abs. 456 (1920)] that the velocity of a chemical reaction is determined by the energy density of radiation of a certain frequency. He assumes the reaction velocity to be proportional to the radiation density $u_\gamma = 8\pi h\nu/c^3(e^{h\nu/kT}-1)$, which may be expressed in the form $U_\nu = Be^{-A/T}$, A and B being constants, so that his theory would lead to Arrhenius' well-known empirical relation according to which the reaction velocity is of the form A/T^2, where T is the absolute temperature. For if v be the reaction velocity, then $1/v \, . \, \partial v/\partial T = A/T^2$, or $d \log v = A dT/T^2$, so that $v = Be^{-A/T}$. If the theory were true the v should undergo great variation by exposure to an external source of radiation, and no such phenomenon has been observed. The author illustrates this by calculating the variation which should, according to the theory, be the result of exposure to sunlight. Taking the sun's effective temperature as 6000°, and its apparent semi-diameter as 16′, the radiation density in the dark should be increased by the exposure in the ratio of $5{\cdot}8 \times 10^{13}$, so that the energy density of wave-length 1·046 μ, which, according to Lewis's theory, determines the reaction velocity, should be increased some 10^{13} times. Actually there is no observable variation. G. W. DE T.

1181. *Solutions of Copper Sulphate in Glycerine for Use as High Resistances.* **A. Gilmour.** (Phil. Mag. 41. pp. 544–548, March, 1921.)—Curves are given showing the specific resistance of solutions of copper sulphate containing various proportions of glycerine, such solutions being suitable for fixed and variable high resistances. L. H. W.

1182. *The Photo-Active Electrolytic Cell, Platinum–Rhodamine-B–Platinum.* **C. C. Murdock.** (Phys. Rev. 17. pp. 626–647, May, 1921.)—*The Range of the Current–Time Equations.*—Goldmann and Thompson have each suggested equations to represent both the growth and the decay of the current given by a photo-active electrolytic cell having electrodes of Pt and an alcoholic solution of Rhodamine-B as electrolyte. The author points out that in each of these equations it is necessary after the first minute of the growth or decay, to use different parameters from those used before and suggests that this may be due to the failure to correct the data for the inertia and damping of the galvanometer coil. A *method for correcting the galvanometer deflections* for these effects is discussed and correction equations are developed.

The polarisation capacity of the cell used is measured by impressing a small p.d. on the cell and observing the instantaneous galvanometer deflections. The capacity as computed from the time constant of the corrected current–time curves gives 26 microfarads per cm.² of each electrode. This is in good agreement with the results obtained by other observers for the capacity of Pt electrodes in aqueous solutions of inorganic substances.

The Dark Current.—Cells having as electrodes sputtered Pt films are found to give a current when not illuminated if the electrodes are not alike. This current tends to flow (*a*) from the denser to the less dense electrode, (*b*) from the warmer to the cooler electrode; its value is independent of the external resistance of the circuit within the range 0 to 1 megohm and decreases slowly as fatigue effects the photoelectric sensitiveness of the cell.

Tests of the Current-time Equations.—Data taken by subjecting the cell to exposures of 10 minutes or more (*a*) cannot be repeated, (*b*) are not when corrected in agreement with either of the above types of equation. Data taken by exposures of 1 minute (*a*) may be repeated very exactly, (*b*) are not, when corrected, in agreement with either type of equation unless the parameters are allowed to change and then only in the case of Goldmann's equation for the growth and Thompson's equation for the decay. In both these cases the change in the parameters occurs at about 8 seconds.

The Hyperbolic Decay Equation.—It is shown that the decay of the current following an exposure of 1 minute or less is well represented throughout the range of experiment by the equation: $y = y_0 - t/Mt = L$, an equilateral hyperbola.

The effect of the length of exposure on the decay is investigated for exposures of 15, 30, and 60 seconds making use of this equation. It is found that the initial rate of decay is independent of the length of exposure. This is shown to be inconsistent with Goldmann's equation. AUTHOR.

1183. *Zinc Electrode.* **W. C. Moore.** (Am. Chem. Soc., J. 43. pp. 81–84, Jan., 1921.)—Confirmation is obtained of the observation that oxygen must be excluded as completely as possible in setting up zinc electrodes. For concentrations varying from 0·5 N to 0·00 N, the method of coating the metal with paraffin wax, covering the electrolyte with paraffin oil and placing scrap zinc in the electrode cells, as advocated by Kistiakowsky, is insufficient. Electrodes reproducible to within ± 0·001 volt may be obtained by preparing the dilute solutions with water recently boiled and cooled in hydrogen, carrying out the dilution in an atmosphere of hydrogen, and making the measurements while hydrogen is bubbled through the electrode vessel. In this way the electrode potentials of zinc in 0·5, 0·1, 0·01, and 0·002 N zinc sulphate solutions at room temperature are found to be − 0·784, − 0·800, − 0·824, and − 0·840 volt respectively, these values being in good agreement with those calculated on the basis of the electrolytic dissociation of the zinc salt; the Nernst electromotive formula is applicable within the range of concentration mentioned. Even with the precautions described, the zinc electrode cannot be applied satisfactorily to the measurement of very small changes in zinc-ion concentration; possibly dilute zinc amalgam electrodes, with extreme precautions for the exclusion of oxygen, would serve this purpose. **T. H. P.**

1184. *Thermal and Electrolytic Production of Potassium Perchlorate.* **E. Blau and R. Weingand.** (Zeits. Elektrochem. 27. pp. 1–10, Jan. 1, 1921.)—That the chlorate $KClO_3$ will on heating yield $KClO_4$ and KCl, O being liberated, has been known since 1831. The authors find that one hour's heating of chemically-pure chlorate at 510° in a Jena-glass flask gives a satisfactory yield. In the presence of small quantities of KOH, Cu, Ni, Fe (slightly oxidised), boric acid, the $KClO_4$ formed is decomposed again at an early stage; some of these bodies are common impurities of the technical chlorate. Iron vessels do not answer; quartz is best. The conversion into perchlorate cannot be completed, but the few remaining per cent. of chlorate can be removed by recrystallisation. Independently of the authors F. Meyer has patented the thermal decomposition at 470° to 520° for $KClO_4$ and at 30 deg. lower for $NaClO_4$ (German Pat. 300,713).

For the electrolysis a current density of 0·15 amp./cm.^{2} (both at the Pt anode and the nickel kathode) at 27° is recommended. It is advisable to electrolyse $NaClO_3$ and to decompose the resulting sodium perchlorate with KCl; the addition of sodium bicarbonate, which improved the electrolytic perborate formation, did not answer; the sodium perchlorate does not encrust the electrodes as $KClO_4$ does. In order to utilise platinum anodes of very thin foil the following arrangement, due to Heraeus, was adopted on the advice of P. Askenasy, under whom the laboratory research was carried out. Pairs of short pins of platinum are soldered to opposite sides of the foil and into a U-tube of glass which thus supports the foil between its limbs; each free end of a pin has previously been soldered to a connecting wire of copper, and these wires are carried up inside the glass tube and cemented in with wax. Barium perchlorate can be obtained by the electrolysis of $BaCl_2$ at 60° with Pt anodes and Ni kathodes also at a current density of 0·15 amp./cm.^{2}. Additions of acetic acid, hydrochloric acid, or calcium chloride, as well as introduction of CO_2, are advantageous; higher temperatures may be favourable. **H. B.**